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CRITERIA 3

3.7.1 – Collaborative Activities

National Level One day Seminar on
"Construction Challenges in the Coastal and Marine Environment

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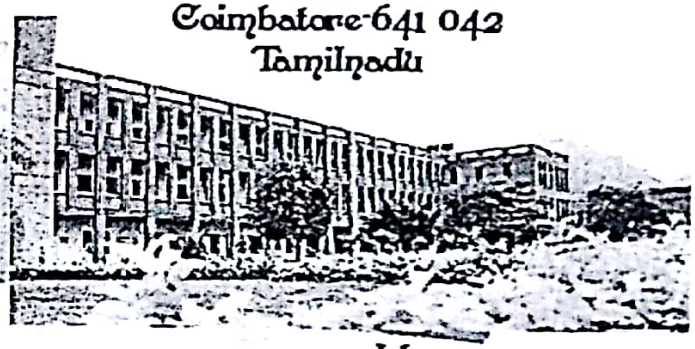

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THE INSTITUTE

SRI KRISHNA COLLEGE OF TECHNOLOGY, formerly known as VLB JANAKIAMMAL COLLEGE OF ENGINEERING AND TECHNOLOGY, is a name synonymous to high quality technical education. The department of civil engineering is old as the institution and was established in 1985. It offers UG degree in Civil engineering and PG degree in Structural engineering. The department is a research centre for those pursuing their Ph.D/M.S (By Research) under Anna University, Chennai.The department is active in research activities related to water, air and soil contamination and remediation.

THE SEMINAR

India is among the 23 nations around the globe where health problems occur due to the consumption of fluoride contaminated water. An estimated 62 million people in India are affected with dental, skeletal and/or non-skeletal fluorosis. Fluoride in excess of 1.0 mg/l causes dental fluorosis. It can also result in skeletal fluorosis and non-skeletal manifestations i.e. loss of appetite, joint pain, stiffness of neck and back pain, gas formation, laziness in routine life, increased urination etc, as commonly reported in fluorotic regions.

Fluorosis, being an untreatable disease, can only be mitigated through prevention and control. Two major interventions: 1) safe water and 2)nutritional supplementation are now practiced in India for combating the health complaints arising due to fluorosis.

A good networking between Public Health Engineering and Health Sector personnel, well-defined objectives for provision of safe/defluoridated water; improvement in the health status of the community through nutritional intervention should be the solutions to tackle the ever increasing fluorosis problem.

The major thrust areas of this seminar are

- To understand the prevalence and effects of dental and skeletal fluorosis in India
- The technology for providing safe water on a sustainable basis
- To emphasizeon the importance of diet for minimizing the adverse effects of fluoride
- To sensitize the people onthe hazards of fluoride contaminated water and
- To initiate the process of chalking out strategies to manage fluorosis

INDIAN COUNCIL OF MEDICAL RESEARCH

The Indian Council of Medical Research (ICMR), New Delhi, is one of the oldest medical research bodies in the world.The Council's research priorities coincide with the National health priorities such as control and management of communicable diseases, maternal and child health, control of nutritional disorders, developing alternative strategies for health care delivery, containment within safety limits of environmental and occupational health problems; research on major non-communicable diseases. All efforts are undertaken with a view to reduce the total burden of disease and to promote health and well-being of the population.In recent years, research has been intensified progressively on emerging health problems arising due to various factors.

SEMINAR ON

FLUOROSIS IN DEVELOPING COUNTRIES : EARLY DETECTION, PREVENTION AND MITIGATING MEASURES

14th September 2015

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Volume - 4 | Issue - 5 | May 2014 | ISSN No 2277 - 8179

Experimental Investigation on Strength Characteristics of Concrete

Engineering

KEYWORDS : Rice Husk Ash, Coir, Environmental Pollution, Compressive Strength, Splitting Tensile Strength, Flexural Strength and Durability.

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Dr.V. Sreevidya | Asso.Prof, Sri Krishna College of Technology, Coimbatore

ABSTRACT *From the investigation this paper express that the strength and durability characteristics of M40 grade concrete in which cement is partially replaced by rice husk ash and coir. Coconut fibers are reported as most ductile and energy absorbent material. It is concluded that coconut fibers have the potential to be used in composites for different purposes. Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. There is a good potential to make use of RHA as a valuable pozzolanic material to give almost the same properties as that of micro silica. In this study, the strength related properties such as compressive strength, splitting tensile strength, flexural strength were calculated and better durability characteristics when compared to other replacement levels.*

INTRODUCTION

Concrete is one of the crucial materials for infrastructure development due to its versatile application, globally its usage is second to water. Due to increase in the cost of conventional building materials and environmental hazard, the designers and developers are looking for 'alternative materials' to reduce the use of cement in civil engineering constructions. For this objective, the researchers are trying to use various waste products in concrete technology. The objective of this investigation is to study the effect of partial replacement of cement by Rice husk Ash as a Mineral admixture in concrete and also adding Natural fiber (Coir) to increase the tensile strength of concrete.

MATERIALS USED AND METHODOLOGY

CEMENT

The Ordinary Portland Cement of 53 Grade conforming to IS 12269 – 1987 was used in this study. The specific gravity, initial and final setting of OPC 53 grade were 3.15, 30 and 600 minutes respectively.

FINE AGGREGATE

Locally available river sand conforming to grading zone II of IS 383 –1970. Sand passing through IS 4.75mm Sieve will be used with the specific gravity of 2.65.

COARSE AGGREGATE

Locally available blue metal was used. Crushed granite stones of size passing through 20mm sieve and retained on 4.75 mm sieve as per IS: 383-1970 was used for experimental purpose.

WATER

Casting and curing of specimens were done with the potable water that is available in the college premises.

RICE HUSK ASH

RHA, produced after burning of Rice husks (RH) has high reactivity and pozzolanic property. Indian Standard code of practice for plain and reinforced concrete, IS 456- 2000, recommends use of RHA in concrete but does not specify quantities. The physical and chemical properties of RHA are shown in Table 1 and Table 2.

Table 1Physical Properties of Rice Husk Ash

Physical properties	Value
Specific gravity	2.19
Fineness passing through 45µm sieve in (%)	99.5
Colour	Grey

Table 2 Chemical Properties of Rice Husk Ash

Chemical properties	Value
Silicon dioxide(SiO_2)	88.32
Silicon dioxide(SiO_2)	0.46
Ferric oxide(Fe_2O_3)	0.67
Calcium oxide(CaO)	0.51
Magnesium oxide(MgO)	0.44
Sodium oxide(Na_2O_3)	0.12
Potassium oxide(K_2O)	2.91

COIR

Coconut fiber is one of the natural fibers abundantly available in tropical regions, and is extracted from the husk of coconut fruit. The aim of this review is to spread awareness of coconut fibers as a construction material in civil engineering. The versatility and applications of coconut fibers in different fields is discussed in detail. Coconut fibers are reported as most ductile and energy absorbent material. It is concluded that coconut fibers have the potential to be used in composites for different purposes.

In civil engineering, coconut fibers have been used as reinforcement in composites for non-structural components. There is a need of investigating the behavior of coconut fiber reinforced concrete to be used in main structural components like beams and columns.

Table 3 Properties of Coconut Fiber

Properties	Value
Fiber length (mm)	50-110
Fiber diameter (mm)	0.1-0.406
Average tensile strength(N/mm²)	150
Specific gravity	1.12-1.15
Elongation (%)	10-25

EXPERIMENTAL INVESTIGATION

MIX DESIGN

Mix design is the process of selecting suitable ingredients of concrete and determines their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

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ADVANCES IN NATURAL AND APPLIED SCIENCES

ISSN: 1995-0772
EISSN: 1998-1090
2016 January 10(1): pages 57-64

Published BY AENSI Publication
http://www.aensiweb.com/ANAS
Open Access Journal

Experimental Study on Flexural and Shear Behaviour of Fibre Reinforced Concrete Beams

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Received 12 January 2016; Accepted 20 February 2016; Available 4 April 2016

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ABSTRACT

This experimental investigation is focus on finding the flexural and shear behaviour of various Fibre Reinforced Concrete (FRC). The fibres used in the investigations are Steel fibre, Recycled Polyethylene Terephthalate fibre (RPET) and Polypropylene (PP) fibre, in the volume fraction of 0.5% of the concrete. And it was compared to the nominal mix of M40 grade of concrete as per IS 10262:2009. Fibres are usually used in concrete to control cracking due to both plastic and drying shrinkage. The mechanical properties of fresh and harden concrete was studied earlier, in that the Polypropylene fibre concrete had good in workability and steel fibrous concrete achieve % strength than the ordinary concrete. Totally three samples were tested for mechanical properties and two samples were tested for flexural and shear beams. The beams were subsequently loaded to failure by two point loading, different modes of failure and the ultimate strength and deflections were observed. The results show that the Steel and Polypropylene fibres were generally contributed towards bridging action and it achieves the maximum strength comparing with the control mix. The RPET fibre is comparatively lower than the other fibre.

KEYWORDS: Fibre Reinforced Concrete, Steel, Recycled Polyethylene Terephthalate, Polypropylene fibre, Mechanical, Shear and Flexural behaviour, bridging action and maximum strength.

INTRODUCTION

Fibre Reinforced Concrete:

Concrete is the most widely used construction material in the world due to its high compressive strength, long service life, and low cost. However, concrete has inherent disadvantages of low tensile strength and crack resistance. To improve such weaknesses of the material, numerous studies on fiber reinforced have been performed Sung Bae Kim *et al* [12]. The research results show that concrete reinforced with steel fibres significantly improves the performance of concrete and the polyethylene refutes its disadvantages such as workability, tensile and shear strength. One of the most important functions of steel fibres in concrete is the ability to transfer stresses across the cracked section, providing to concrete a residual strength, which magnitude depends on the fibre, matrix and fibre-matrix properties Yining Ding *et al* [14]. Addition of randomly distributed fibers (steel, synthetic) drastically improves the performance of concrete and negates its disadvantages such as low tensile strength, low ductility, low energy absorption capacity and high shrinkage cracking etc., which depends upon fiber type, size, aspect ratio and volume fractions of the fibers used.

Flexural and Shear behaviour:

To Cite This Article: Karthik M.P., Dr. Sreevidya V., Dr. Robert Ravi and M. Gowtham Raj., Experimental Study on Flexural and Shear Behaviour of Fibre Reinforced Concrete Beams, 2016. Advances in Natural and Applied Sciences. 10(1): Pages: 57-64

IJIRSET

ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Waste Foundry Sand as a Replacement for Fine Aggregate in High Strength Solid Masonry Blocks

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ABSTRACT: The management of solid industrial waste is of big global concern nowadays. The majority of industries are not interested in the treatment and safe disposal of industrial waste due to its high cost involvements, causing environmental and other ecological impacts. The disposal of waste foundry sand is of prime importance due to the big volume produced from the foundries all over the world. Moreover solid masonry blocks which are widely used in construction purposes are structurally inferior to burnt clay bricks. This also has a disadvantage that it cannot be used for load bearing and seismic resistant structures. This paper mainly targets on two solutions: making of commercially available solid masonry blocks to high strength so that it can be used in load bearing structures and replacement of fine aggregate in these blocks with waste foundry sand. Although many studies have been formulated using waste foundry sand in concrete, no such study has been reported so far with solid masonry blocks. Design of blocks were made following IS: 10262(2009) guidelines and testing of blocks were satisfied using IS: 2185(1979).It was inferred that about 20 to 30 percent of replacement of fine aggregate to waste foundry sand gave good results for all practical purposes. This study also aims to encourage industries to start commercial production of concrete products using waste foundry sand.

KEYWORDS: High strength solid masonry blocks, waste foundry sand, chemically bonded foundry sand, compressive strength

I. INTRODUCTION

Natural sand has been used widely in construction activities and is diminishing day by day. At present due to the unavailability of natural sand, manufactured sand produced from quarries are widely used for mass production of concrete. Very soon in the near future there will be a scarcity for manufactured sand also. Use of recycled products is the new trend in industry and researchers are keen to find a new material that fit for the right purpose. Here waste foundry sand can be effectively utilized as partial or full replacement of natural sand or manufactured sand. Waste foundry sand (WFS) is a by-product of the metal casting industries generated from the released moulds for casting after several reuses [1]. Foundry sand is basically high quality silica sand. Depending upon the type of binders used, waste foundry sand or used foundry sand can be classified into green sand and chemically bonded sand. In green sand the binder used is bentonite whereas in chemically bonded sand it is mainly of organic system [2]. Due to the chemicals present in the binders the disposal of waste foundry sand for land filling may cause adverse environmental and ecological impacts. Due to high treatment cost, foundry industries are not much interested to invest on the safe disposal of waste sand. As per present disposal practices, the waste foundry sand which is dumped on barren land cannot be recovered. So the waste foundry sand should be used for other beneficial applications to reduce its adverse effects. In this study the properties of high strength concrete masonry blocks with partial replacement of waste foundry sand to fine aggregates are examined. This alternate use is also advantageous in saving of natural resources like river sand, which is in threat of depletion. It can also save the natural rock deposits to some extent as nowadays manufactured sand

DOI:10.15680/IJIRSET.2016.0505037

Journal of Environmental Management
Volume 181, 1 October 2016, Pages 847-855

Research article

Synthesis, characterization and performance of high energy ball milled meso-scale zero valent iron in Fenton reaction

Selvaraj Ambika, M. Devasena, Indumathi Manivannan Nambi
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https://doi.org/10.1016/j.jenvman.2016.06.054

Highlights

- Use of High energy ball milled meso ZVI (mZVI) in Fenton reaction was studied.
- Iron speciation and oxidant analysis speculate Ferryl species at circumneutral pH.
- Dissolved Fe ions easily migrate across mZVI's oxide film than nano ZVI.
- Unbuffered systems showed efficient degradation with less residual iron and sludge.
- *In-situ/ex-situ* treatment using scarp ZVI without buffer/stabilizer is possible.

Abstract

Understanding contaminant degradation by different sized zero valent iron (ZVI) particles is one important aspect in addressing the long-term stability of these particles in field studies. In this study, meso zero valent iron (mZVI) particles were synthesised in a milling time of 10 h using ball milling technique. The efficacy of mZVI particles for removal of phenol was quantitatively evaluated in comparison with coarse zero valent iron (cZVI) and nano zero valent iron (nZVI) particles. Phenol degradation experiments were carried out in sacrificial batch mode at room

Asian Research Consortium

Asian Journal of Research in Social Sciences and Humanities
Vol. 6, No. 10, October 2016, pp. 761-769.

Asian Journal of Research in Social Sciences and Humanities

www.aijsh.com

ISSN 2249-7315
A Journal Indexed in Indian Citation Index
DOI NUMBER: 10.5958/2249-7315.2016.01050.9
Category:Science and Technology

Water Quality Index of Cauvery River and its Three Tributaries, South India

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Abstract

Various physico-chemical parameters including selected heavy metals (As, Cu, Zn, Pb, Cd and Cr) of the Cauvery River and its three tributaries were studied in order to understand the level of contamination due to anthropogenic and natural impacts in the river basin. It was found that the water quality of Cauvery and Bhavani rivers varied from Excellent to Marginal range for drinking, whereas Noyyal River was found unfit for drinking purposes. It was observed that the impact of human activity was severe on most of the parameters in these rivers. According to the water quality index, the water quality was found to be excellent with WQI less than 50 in all the samples of Bhavani and Cauvery Rivers. The water quality was good in Amaravti River during post-monsoon and it was found unfit for drinking during NE-monsoon at few places. All the samples of Noyyal River had WQI values above 300 and were found unfit for drinking in both the seasons and seeks immediate attention. Even though the parameters analysed are all within the safe limits in Cauvery River, it would be better to treat the sewage before discharging into the rivers from the human settlement areas.

Keywords: Cauvery River; Heavy metal concentration; Water quality index; Noyyal River.

1. Introduction

Water is the most precious gift nature has given to mankind. Unlike other resources, water does not have a substitute in its main uses and it cannot be replaced. Virtually, no activity in the environment

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International Journal
of Earth Sciences
and Engineering

ISSN 0974-5904, Volume 09, No. 03

June 2016, P.P.487-490

Study on Magnesium Potassium Phosphate Cement Blended With Fly Ash by Concentric Loading Test

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Abstract: One of the main ingredients used for the production of concrete is the Ordinary Portland Cement (OPC). Carbon-dioxide (CO_2) gas which is a major contributor in greenhouse effect and the global warming, is produced in the production of cement, hence it is needed either to search for another material or partially replace cement by some other material. In recent years, fly ash when replaced with cement has emerged as a major alternative to conventional concrete and has rapidly drawn the concrete industry attention due to its cement savings, energy savings, and cost savings, environmental and socio-economic benefits. Magnesium potassium phosphate cements (MKPCs), blended with partially weight percentage of fly ash (FA) to reduce heat evolution, water demand and cost, were assessed using compressive strength. In addition to the main binder phase, struvite-K, an amorphous orthophosphate phase was detected in FA/MKPC system. It was postulated that an aluminium-phosphate phase was formed; however, no significant Al–O–P interactions were identified. This study demonstrates the need for further research on these binders, as FA is generally regarded as inert fillers within MKPC. The effects on using MKPC concrete of various mix(20%,30%,40% and 50%) was studied by workability, compressive strength & split tensile strength. The durability study by sulphate attack test was performed. The concentric load behavior will be monitored in column by casting with optimum percentage mix of MKPC/Fly ash concrete.

Keywords: *MKPC, Struvite-k, Fly ash, Aluminium-phosphate phase*

1. Introduction

Magnesium potassium phosphate cement (MKPC) is a kind of cementitious binder in which the chemical bond is formed via a heterogeneous acid-base reaction between dead burned magnesia powder and potassium phosphate solution at room temperature. Small amount of boron compounds can be incorporated in the cement as a setting retarder. The chemical reaction resulting in the formation of MKPC's is based on the dissolution of MgO and KH_2PO_4 reacting in solution to form struvite-K ($MgKPO_4 \cdot 6H_2O$), which is iso-structural to struvite ($NH_4MgPO_4 \cdot 6H_2O$) and is naturally cementitious.

$$MgO + KH_2PO_4 + H_2O \rightarrow MgKPO_4 \cdot 6H_2O$$

In practical application, MKPC binders are frequently blended with fly ash (FA) from the coal combustion process to reduce their production cost, reduce water demand of the paste, and lower the exothermic output of the acid–base reaction which avoids cracking of the hardened paste. Alumino silicate glass can react with phosphoric acid to form strong phosphate bonded cement. It is conceivable that the glassy alumino silicate fraction of the FA reacts in the initially acidic environment of the MKPC, forming a secondary phase intermixed with struvite-K. If this occurs, it could result in a matrix of higher density that would be more impermeable to water, have a higher mechanical strength.

2. Material Properties

The properties of materials used in the concrete are discussed below:

2.1 MKP Cement

The reaction product is magnesium potassium phosphate ($MgKPO_4 \cdot 6H_2O$) that is formed by dissolution of MgO in the solution of KH_2PO_4 and its eventual reaction to form the product according to the reaction.

2.2 Fine Aggregate

The sand sieved through 4.75 mm sieve is used having specific gravity of 2.74. The fine aggregates belonged to grading zone III.

2.3 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 12.5 mm is used. The specific gravity of coarse aggregate that was taken was 2.74.

2.4 Fly ash

Fly ash is used as a replacement for cement. The specific gravity of fly ash that was taken was 2.2.

2.5 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with

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ISSN 0974-5904, Volume 09, No. 03

International Journal of Earth Sciences and Engineering

June 2016, P.P.604-607

Experimental Stability Analysis of Porotherm Infill Slabs

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Abstract: Concrete is the one of the construction material produced worldwide. Here is the method to make the effective use of the material. In a simply supported RCC slab, the upper part of the slab is subjected to compressive forces while the lower portion is subjected to tensile forces. Concrete is very good in compression while it is weak in tension. Hence the steel reinforcement is placed in the tension zone. The concrete in this portion is only for holding together the steel reinforcement and has no structural purpose. By choosing the filler material judiciously, we could save about 30-35% of concrete compared to a traditional RCC slab. A light weight filler material also reduces the dead load hence less steel reinforcement is required. In all we may expect to save about 25% of the cost .And for strength and stability conditions is tested for the slabs with normal reinforcement and steel fiber strips. Finally the stability analysis of the slab element is done and the comparative results will be given.

Keywords: Porotherm blocks, Flexture strength, compressive strength, Stability, Deflection

1. Introduction

Porotherm is the clay block used for the masonry works. It acts as a light weight infill Material. Construction block technology offers a speedier, cost effective, environmentally sound alternative to conventional walling materials. It is based on the principle of densification of a lean concrete mix to make a regular shaped, uniform, high performance masonry unit. This technology can be easily adapted to suit special needs of users by modifying design parameters such as mix proportion, water/cement ratio and type of production system. To make the effective usage of the building materials like concrete and steel .And to have the stability to withstand the loads acting on the elements. The structure is long lasting with marvelous features. Pre-cast concrete roofs are smooth. This type of concrete in roofing and sunshade accessory will be resistant to the extreme weather condition.

2. Aim and Objective

The main objective

- To analyze the stability of the pre cast slab elements.
- To reduce the self-weight of the slab elements.
- To reduce the cost.
- To make the better finish.
- To make the efficient use of building materials

3. Description of the Porotherm Blocks

Offering exceptionally fast, virtually dry construction, plus high strength and thermal efficiency, Porotherm is a modern clay block structural walling system with reassuringly traditional values. A natural progression from handmade bricks to engineered blocks; it is widely used and has been proven on millions of projects for over 30 years in Europe in both domestic and commercial applications, and is ideal for use on projects from single storey to Multiple-storeys.

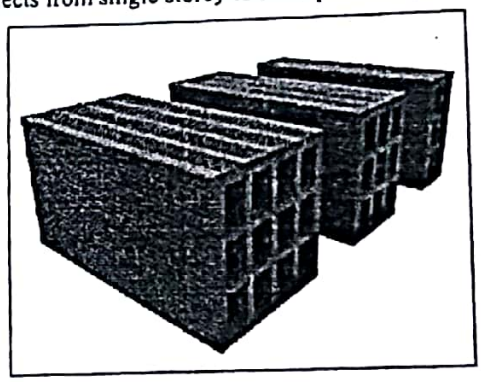

Fig-1 Showing the Porotherm blocks of the different sizes

Porotherm is a highly efficient alternative to other building materials such as timber, concrete or light steel frames and is suitable for a variety of construction applications. Each Porotherm block is a precision designed and engineered vertically perforated walling unit made from prepared clay, (with typically 20% recycled materials e.g. sawdust, paper or minerals).

Types of Porotherm

Offering exceptionally fast, virtually dry construction, plus high strength and thermal efficiency, Porotherm is a modern clay block structural walling system with reassuringly traditional values.

There are two type of porotherm brick is available, thus are,

- Porotherm HP (Framed Structure).
- Porotherm VP (Load-Bearing Structure).

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ISSN 0974-5904, Volume 09, No. 03

International Journal of Earth Sciences and Engineering

June 2016, P.P.544-548

Flexural Behaviour of Reinforced Beam using Self-compacting Concrete

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Abstract: In recent years, Self-compacting concrete (SCC) gained wide use for the placement in the congested reinforced structure with difficulty in casting condition. For, such applications fresh concrete must possess high fluidity and good cohesiveness. One of the disadvantages of Self-compacting concrete is its cost by usage of high volume of Portland cement and chemical admixture. One alternative to reduce the cost of Self-compacting concrete is by adding mineral admixture such as Silica Fume as replacement cement by 5%, 10%, 15% and 20%. Moreover, by the addition of mineral admixture in the manufacturing of Self-compacting concrete not only it reduces the cost but also reduces the heat of hydration, also parameters like environmental consciousness, sustainable development plays important role in future. So keeping that in mind the research is made with partial replacement of foundry sand with fine aggregate by 50%. Knowing that concrete is weak in tension, Glass fibre are added by 1% to improve the tensile property. The initial results of experimental programs aimed at producing and evaluating SCC made with fly ash, silica fume, foundry sand and Glass fibres are presented and discussed. The mix design of SCC was arrived as per guidelines of European Federations of National Associations Representing for Concrete (EFRNAC). Based on the results obtained from the comparison study of SCC with fly ash and silica fume the results have concluded that the use of fly ash increases the early age strength and the addition of silica fume increases the latter age strength of the concrete. To study the flexural behaviour of Self-compacting concrete and taking consideration of latter age strength of concrete a beam of size 100 x 200mm and span of 1m is cast and tested for its flexural properties.

Keywords: Self-compacting concrete, Fly ash, Silica fume, Foundry sand, Glass fibre and Hardened properties

1. Introduction

Self-Compacting Concrete (SCC) is a concrete which can be placed and compacted under its own weight with little vibration. Self-compacting concrete is cohesive enough to be handled without bleeding and segregation. SCC was first developed in Japan in late 1980's to be used mainly in congested reinforced areas.

The increase of paste volume with emphasis to low water powder ratio (w/p) in the presence of compatible chemical admixtures further strengthens the fluidity and helps in attaining homogeneity. Adequate homogeneity improves viscosity of the mix, which in turn enhances the segregation resistance. An optimum balance between fluidity and viscosity is the key to achieve efficient self-compacting characteristics of the concrete mix in fresh state.

1.1. Properties of Self-compacting Concrete

Fresh SCC should possess the following key properties related to workability:

1.1.1. Filling ability: This is the ability of SCC to flow, spread and fill into spaces under its own weight. Slump flow test, V-funnel test and orimet test are conducted to measure the filling ability of SCC.

1.1.2. Passing ability: This is the ability of SCC to flow through close spacing such as reinforcing bars under its own weight without blocking. L-box, U-box and fill box test are conducted to measure the passing ability.

1.1.3. Resistance to segregation: The SCC must meet the required levels of properties and its composition must remain uniform throughout the process of transport and placing. GTM test and V-funnel at T_{5min} are conducted to measure the property.

2. Material Properties

2.1 Cement

Ordinary Portland cement of grade 43 is used with confirmation to IS 8112-19890. Its physical properties are given in the table 1.

Table 1: Physical Properties of Cement

S.No.	Physical Properties	Values
1.	Specific gravity	3.14
2.	Initial setting time	90min
3.	Final setting time	300min
4.	7 days compressive strength	34 N/mm^2
5.	28 days compressive strength	45 N/mm^2

Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 03, March-2019

Study on Mechanical Properties of Self Compacting Concrete with Mineral Admixture and Glass Fibre

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Abstract— **In recent years, Self Compacting Concrete (SCC) has gained wide attention owing to their placement use in congested reinforced structures with difficulties in casting condition. For such applications fresh concrete must possess high fluidity and good cohesiveness. One of the disadvantages of self compacting concrete is its cost due to the usage of high volume of Portland cement and chemical admixture. One way to reduce the cost of self compacting concrete is by adding mineral admixtures such as fly ash, silica fume as a replacement to cement by 5%, 10%, 15% and 20%. Moreover, by the addition of mineral admixture in the manufacturing of self-compacting concrete, cost and heat of hydration get reduced. Also parameters like environmental consciousness and sustainable development plays an important role. Keeping this in mind, research was carried out by partial replacement of foundry sand with fine aggregate at 50%. Knowing that concrete is weak in tension, glass fibres are added at 1% to improve the tensile property. The initial results of experimental programs aimed at producing and evaluating SCC made with fly ash, silica fume, foundry sand and glass fibres are presented and discussed. The mix design of SCC was arrived as per guidelines of European Federation of National Associations Representing for Concrete (EFRNAC).**

Keywords— Self compacting concrete, Fly ash, Silica fume, Foundry sand, Glass fibre, Hardened properties.

I. INTRODUCTION

Self-Compacting Concrete (SCC) is a concrete which can be placed and compacted under its own weight with little vibration. Self-compacting concrete is cohesive enough to be handled without bleeding and segregation. SCC was first developed in Japan in late 1980's to be used mainly in congested reinforced areas.

The increase of paste volume with emphasis to low water powder ratio (w/p) in the presence of compatible chemical admixtures further strengthens the fluidity and helps in attaining homogeneity. Adequate homogeneity improves viscosity of the mix, which in turn enhances the segregation resistance. An optimum balance between fluidity and viscosity is the key to achieve efficient self-compacting characteristics of the concrete mix in fresh state.

II. BACKGROUND AND RELEATED WORKS

Concrete is a mixture of cement, fine aggregate, coarse aggregate, water and sometimes chemical and mineral admixture. Due to increase in construction activities, the demand of concrete is increasing and at a certain point of time the availability of cement and other constituents of concrete will be exhausted. This can be reduced by the use of waste materials (or) by-products from the industries as a replacement material which will not affect the concrete properties. Past research have concluded that the use of fly ash, silica fume and foundry sand increases the mechanical properties of concrete and also by addition of these materials in Self Compacting Concrete (SCC) there is negligible change in properties. In [1, 2, 3] the cement is replaced with fly ash by a maximum of 50% and has shown that the addition of fly ash will increase the flow property and strength parameter of the Self Compacting Concrete (SCC). From [4, 5] the cement is replaced with silica fume, a by-product obtained from ferro-alloy industry. By replacing it with cement by 20% an increase in the strength properties is noted and it affects the flow ability of the Self Compacting Concrete (SCC). The black foundry sand can be used in concrete compared to other foundry sands [6]. In [7, 8] the incorporation of waste foundry sand increased the hardened properties of self compacting concrete by a huge margin compared to normal concrete. [9] Addition of fly ash not only increases the hardened properties of concrete but also the tensile property knowing that glass fibre is adopted to increase the tensile property of self compacting concrete. [10] Addition of glass fibre by 1-1.5% increases the tensile property of self compacting concrete by 5% compared to normal concrete.

III. MATERIAL PROPERTIES

A. *Cement*

Ordinary Portland cement of grade 43 is used with confirmation of IS 8112 – 19890. Its physical properties are given in the table 1.

TABLE 1 Physical properties of cement

S.No.	Physical Properties	Values
1.	Specific gravity	3.14
2.	Initial setting time	90min
3.	Final setting time	300min
4.	7 days compressive strength	34 N/mm^2
5.	28 days compressive strength	45 N/mm^2

B. *Fly ash*

Class F fly ash obtained from thermal power plant is used for the process. The physical properties are given in table 2.

Asian Research Consortium

Asian Journal of Research in Social Sciences and Humanities
Vol. 7, No. 3, March 2017, pp. 26-42.

ISSN 2249-7315
A Journal Indexed in Indian Citation Index
DOI NUMBER: 10.5958/2249-7315.2017.00158.7
Category:Science and Technology

Asian Journal of Research in Social Sciences and Humanities

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Suitability Analysis of Ground and Tank Water Quality for Domestic Purpose along Downstream Side of Coimbatore City

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**Department of Civil Engineering,
Sri Krishna College of Technology,
Coimbatore, India.

Abstract

The tribulations of water quality have grow to be more significant than the quantity, as the environmental harms are receiving more severe in diverse parts of our planet. The supervision of the groundwater supply is a tough job globally next to the surroundings of the increasing water demand for living and non living things. This research work is linked together water qualit and quantity, which is flattering more severe owing to populace detonation, rising in farming and enhanced standard of living. This study aims to estimate the category of surface water and groundwater quality. Also to examine the interface of surface water and groundwater which is decisive in categorize to identify the special effects of best management practices on the complete scheme of water resources. For this study, four downstream tanks such as selvachindhamani, ukkadam big tank, valankulam, singanallur tankwere choicen from coimbatore city, considering these tanks were comparatively polluted due to manufacturing and municipal intervention. This study focused on ground water and surface water interactions using MODFLOWat large exclusively as a groundwater-flow simulation model.MT3D package from Visual MODFLOW was used to simulate the contaminant transport due to advection and dispersion. Semi-structured interview was prepared in the study area after acquiring the water quality test results. In view with the response given by the public, Source for drinking water, method of waste disposal and spread of disease among the people were analyzed. 50% of the people living nearby to the tanks dispose the waste into the tank, which is the most important cause for water quality deterioration.

co-educational Engineering College was started in 1985 under the auspices of VLB Educational Trust, a Charitable Educational Trust located in congenial environment 6 Km from the city limits and 7 km from Coimbatore - Palakad NH. The College campus spreads over a sprawling 130acres and is well maintained with dedicated efforts for more than three decades. All the UG programmes offered are accredited by the National Board of accreditation.

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Dr.I. Padmanaban, HOD, with a strong team of faculty provides the right academic atmosphere for the students to get development into complete Civil Engineers with Aptitude and Research. In the past Three decades, the Department has seen lot of progress in Academics and Research and Consultancy. The Department boasts in conducting PG Course in STRUCTURAL ENGINEERING. In addition, the Department is recognised as a Research Centre by Anna University, Chennai. So far about 15 Scholars have acquired Ph.D. Quality of students and their achievements in Curricular and Co-Curricular activities have branded our Department as leading centre for learning

Industrial Aspects of Cold Formed Steel Structures

on
06.04.2017

ORGANISED BY
DEPARTMENT OF CIVIL ENGINEERING
SRI KRISHNA COLLEGE OF TECHNOLOGY, COIMBATORE

In association with CSIR

ABOUT THE PROGRAMME

Steel Structures:- Steel is an [illegible] construction material. The [illegible] approach to design and construction of steel structure is usage of hot rolled steel sections. The use of cold-formed steel members in building construction began in the 1850s in both the United States and Great Britain.

In the past, cold-formed steel sections were used as secondary structural members, for example, roof purlin and side rail for wall cladding. As the industry demand grows the use of cold-formed steel members as primary structural members, for example, roof truss, beam and column member, the cold-formed steel structures are relatively new technology.

The purpose of this workshop is to provide wide exposure about the cold formed steel sections, its usages with structural aspects and it is useful to upgrade the knowledge in the new technology.

Objectives:

To understand basics concepts and recent developments in

1) Forms of light cold formed sections
2) Local buckling concept
3) Cold formed compression and tension members
4) Lateral buckling concept
5) Cold formed beams

About CSIR: The Council of Scientific & Industrial Research (CSIR) --the premier industrial R&D organization in India was constituted in 1942 by a resolution of the Central Legislative Assembly. It is an autonomous body registered under the Registration of Societies Act of 1860.CSIR aims to provide industrial competitiveness, social welfare, strong S&T base for strategic sectors and advancement of fundamental knowledge.

Today CSIR is recognised as one of the world's largest publicly funded R&D organisations having linkages to academia. R&D organisations and industry. CSIR's 37 laboratories not only knit India into a giant network that impacts and add quality to the life of each and every Indian but CSIR is also party to the prestigious Global Research Alliance with the objective of applying global knowledge pool for global good through global funding.

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1. Students and Academicians
2. Industrial Practitioners

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REGISTRATION FEE Rs 200/- for all participants.

VENUE

Date: 06.04.2017
Time: 09.30 AM

Electrical Science Block Seminar Hall,
Sri Krishna College of Technology Coimbatore - 641042

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SRI KRISHNA INSTITUTIONS COIMBATORE

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FRONTLINE AREAS OF CIVIL ENGINEERING

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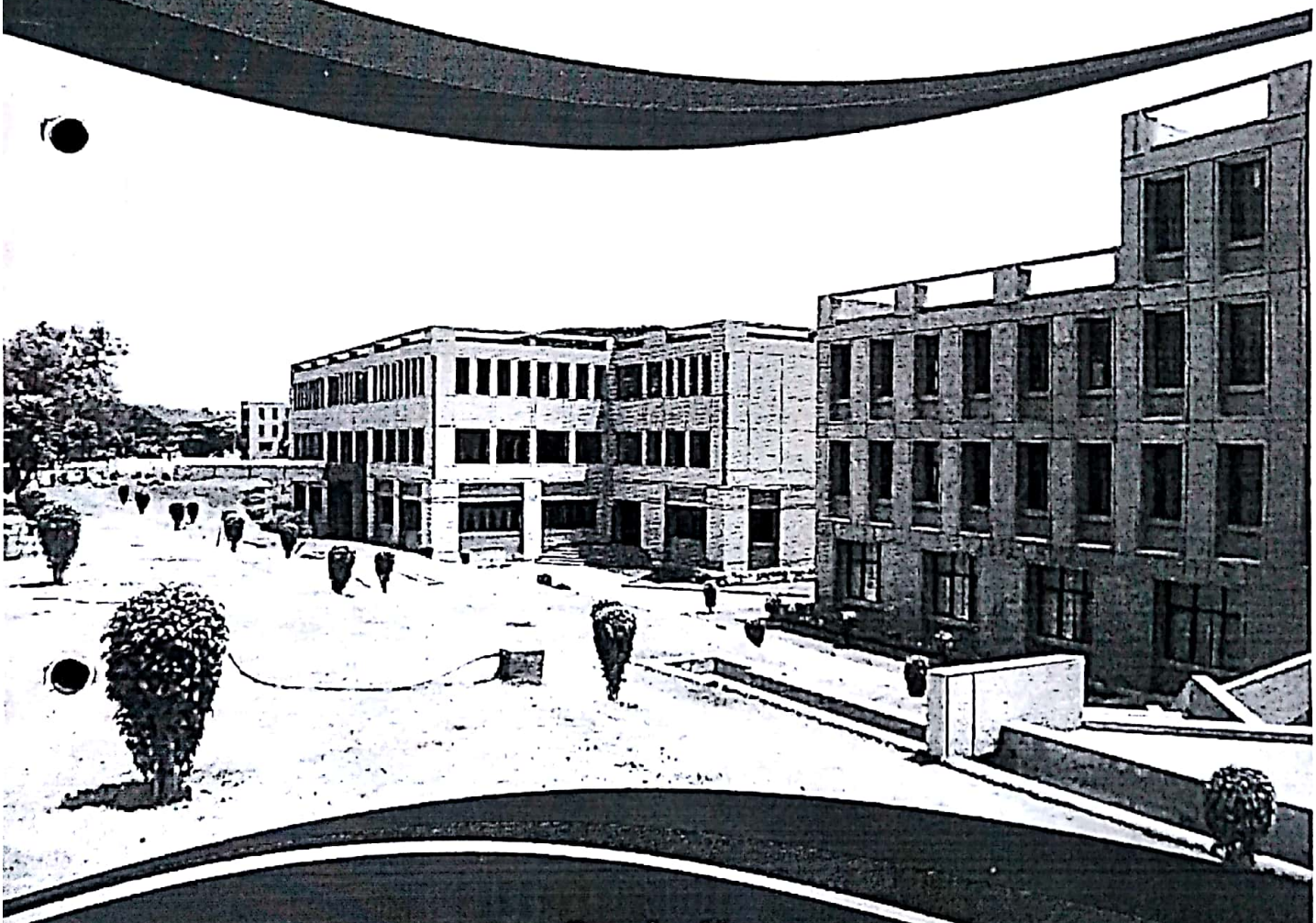

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About the Conference

Sri Krishna College of Technology (SKCT), Coimbatore, Tamil Nadu, India is organizing 3rd International Conference on Frontline Areas of Civil Engineering (ICFACE-2018) during January 5th & 6th, 2018. Conference aims to bring together and provide a platform to Researchers, Engineers, Scientists and Academicians as well as Industrial Professionals from all over the globe to present, share and exchange their research results and developmental activities about all parts of Civil Engineering. ICFACE-2018 is unique in itself due to fusing Civil Engineering, which helps the delegates to exchange their experiences face to face, establish research relations and to find global partners for future research collaboration.

About 3rd ICFACE-2018

SKCT has organized 2 International Conferences on its own banner and has more enormous contributions to all walks of life. SKCT has organized First International Conference on Advances in Materials and Techniques in Civil Engineering (ICAMAT-2010) during January 7th - 9th, 2010 and Second International Conference (ICAMAT-2014) on January 9th -11th, 2014 respectively in association with Department of Civil Engineering. Research has played an indispensable role in many useful developments. Pursuit of newer and innovative ideas has no limits and therefore activities of research have to continue and grow. The aim of this Conference is to discuss topics ranging from technical to social and economic issues, and to exchange experience and knowledge between people from industry and academia around the world.

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Sri Krishna College of Technology (SKCT), Coimbatore, private co-educational Engineering College was started in 1985 under the auspices of VLB Educational Trust, a Charitable Educational Trust located in congenial environmental 6km from the city limits and 7km from Coimbatore Palakad NH. SKCT is march in forward in all aspects under the leadership of the Principal Dr.A.Ramesh. The College campus spreads over a sprawling 1[illegible]res and is well maintained with dedicated efforts for more than three decades. All the UG programmes offered are accredited by the national board of accreditation.

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The International Conference program will consist of plenary addresses, keynote addresses by eminent scientists/academicians and technical paper presentations. Papers are invited from Academicians, Researchers, Engineers, Scientists, Research Scholars and students as well as Industrial Professionals from all over the globe. The authors are requested to submit full paper within 8 pages as per IEEE format on or before the deadline. The full paper should include cover letter and full details (affiliation, address, telephone, fax, email id and other contact information) of the corresponding author. Full papers submitted by authors will be peer double blind reviewed by the Technical Committee members, papers presented during the conference will be published in the scoupus indexed journals and based on reviewer's comments/suggestions will be selected for oral presentation during the conference.

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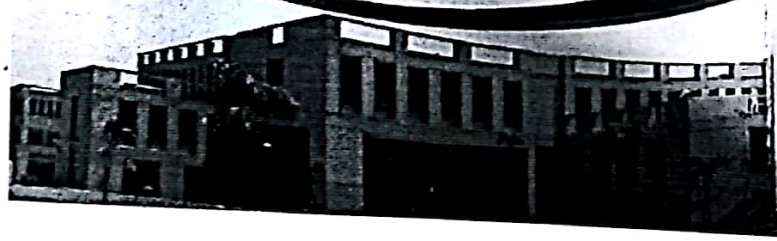

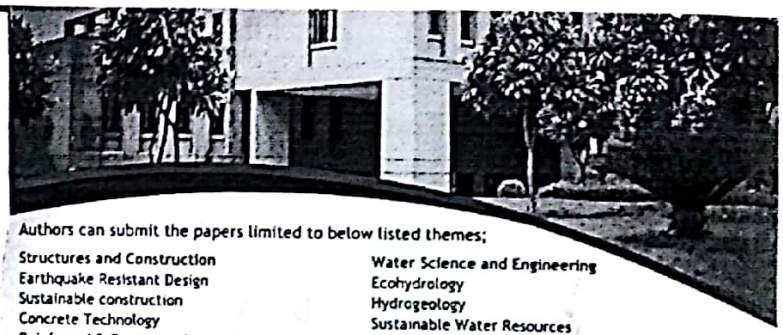

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Intimation of Accepted Papers	: Nov 15th, 2017.
Registration	: Dec 6th, 2017.
Conference Dates	: Jan 5th & 6th, 2018

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Eco. Env. & Cons. 23 (1) : 2017; pp. (245-255)
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ISSN 0971–765X

Application of remote sensing & Gis for demarcation of groundwater potential zones in a part of cauvery river basin, South India- A Case Study

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(Received 21 June , 2016; accepted 10 August, 2016)

ABSTRACT

Surface water sources are rather inadequate in peninsular India to fulfil the demand and have to be supplemented with groundwater. Productivity through groundwater is quite high as compared to surface water. Cauvery basin is one of the best regulated and fully exploited basins and no documented estimates of groundwater are available for the basin in the central part of Tamil Nadu region. The present study is an attempt to delineate the groundwater potential zones in the central part of Cauvery river basin, South India using integrated approach of Remote Sensing and GIS techniques. Various geological and geo-morphological factors play a major role in the occurrence, movement and potential of ground water sources. Survey of India (SOI) Topographic maps and LANDSAT TM satellite images were used to prepare various thematic layers such as geology, geomorphology, drainage pattern, lineaments, soil and slope, which influence the occurrence, movement, yield and quality of groundwater. All these themes and their individual features were then assigned weights according to their relative importance in groundwater occurrence. The thematic layers are then integrated using ERDAS image processing software and by employing raster calculator tools in ArcGIS platform, a composite groundwater potential index (GWPI) for the study area was generated on the basis of which the overall groundwater potential map was produced. Three categories of groundwater potential zones were delineated as poor; moderate and high. Groundwater occurrence is categorized as 'poor' in 63.34% of the study area which substantiates artificial recharge to augment groundwater in the region.

Key words : Groundwater potential zones; Remote sensing and GIS; Geomorphology; Drainage density; Lineament density; Cauvery River basin; India

Introduction

The incessantly increasing population in the developing world, especially in India, coupled with increasing agricultural and industrial development poses larger demand for essential public utilities, particularly, water supply for domestic, agricultural and industrial needs. However, the reality of poor economic situation and challenges of expansion of many basic infrastructural facilities to meet the increasing demand on the parts of the government warrants the need for individuals and local communities to look for sustainable alternative to the conventional public water supply (Aggarwal *et al.*, 2009;

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Indian Journal of Ecology (2017) 44 (2): 000-000

Manuscript Number: 2462
NAAS Rating: 4.96

Scientific Methods of Assessing Groundwater for Irrigation Purpose – A Case Study in a Part of Cauvery River Basin, South India

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Abstract: In present study, an attempt is made to evaluate the quality of groundwater for intended usage for irrigation in Cauvery river basin on the basis of various criteria like Salinity Hazard, Sodicity Hazard, Alkalinity Hazard, Permeability Hazard and Specific ion Toxicity. Gibbs plot suggests that rock-water interaction is the main mechanism of geochemistry in the area. The ground water of the study area is generally low alkaline and high saline in nature. A total of 78 samples out of 100 groundwater samples have been found to fall under suitable category for irrigation based on the analysis of the indices. Samples represent high to very high saline and alkaline categories in regions of confluence of Noyyal and Amaravati rivers with Cauvery and also in agricultural belts of Bhavani river basin. Special types of irrigation methods are essential in such stations to control the high salinity consequently improving the yield.

Keywords: Groundwater; Cauvery river basin, Irrigation water quality; Gibbs plot; Wilcox plot

Water pollution across river basins varies in severity depending on the degree of urban development, agricultural and industrial practices and systems for collecting and treating wastewater (https://www.idfc.com/pdf/report/2011/Chp-1-A-River-Basin-Perspective-of-Water-Resources-and-C.pdf, 2011). The irrigated areas in the Cauvery basin have increased considerably from about 620,000 hectares to 850,000 hectares, but proportionately increasing the water demand also. The groundwater levels within the basin range from less than 10 m during the post monsoon period to as deep as 50 m during the hot summer months and the beginning of the Southwest monsoon (François Molle and Philippus Wester, 2009). The competition for water resources in the Cauvery basin and its sub basins has increased pertaining to the rapid changes in water use. The quality of water has become a major threat in most of the river basins in India. Nearly about 70 per cent of the surface water resources and large proportions of groundwater reserves have been contaminated due to indiscriminate discharge of wastewater from the industry, agriculture, and domestic sectors which contain toxic organic and inorganic pollutants. The Indian peninsular rivers are principally fed by rain. During summer, their flow is greatly reduced, and some of them even dry up, until they get recharged in the next monsoon. Nearly all waters contain dissolved salts and trace elements, many of which result from the natural weathering of the earth's surface. In addition, drainage waters from irrigated lands and effluent from city sewage and industrial waste water can impact water quality. The pollution of water resources caused by the discharge of untreated municipal sewage and industrial effluents, and agro-chemical contamination of groundwater has further intensified the claim of good quality water.

The stress on water resources is apparently increasing due to the rising demands and the deteriorating quality of water. In many regions in India, the extraction of groundwater is more than the recharge. The groundwater resource has been exploited to the extent that, many regions in the country are facing severe problems. The overexploitation of groundwater has resulted in a number of problems, such as sea water ingression in coastal areas and pollution in different parts of the country. Groundwater is also polluted due to point and nonpoint source pollution. For example, occurrence of high fluoride content has been reported in 13 States in India. Other pollutants, such as arsenic in West Bengal, and iron in the north-eastern states, Orissa, and other parts of the country have also been reported. In the canal irrigated land of Haryana, Punjab, Delhi, Rajasthan, Gujarat, Uttar Pradesh, Karnataka, and Tamil Nadu, groundwater is affected due to salinization (the affected area comprises over 193,000 km^2 of land) (CWC Report, 2014).

Irrigation is essential for agricultural production in infertile and semiarid regions where rainfall is not sufficient to uphold crop growth. Irrigated agriculture consumes 60–80% of the total water usage and contributes nearly 38 % of the global food production. It has proved to be a principal factor in generating employment opportunities in the rural areas and providing food for affordable prices for downtrodden people in the urban area (Shahinasi and Kashuta, 2008).

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ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.8, pp 13-20, 2017

Behaviour of Hybrid Fibre Reinforced Self Compacting Concrete using Foundry Sand

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Abstract : The construction activities in the last few decades have increased many folds in almost all the developing countries of the world. Sand is becoming a scarce commodity globally because of its growing demand day by day. It is the need of time to search such alternative materials that would partially or fully replace sand used in concretes without affecting its quality, strength and other characteristics. In order to reduce time and to improve the filling capacity of highly congested structural members by its own weight without any vibration self-compacting concrete (SCC) is adopted.

The primary aim of this study is to explore the feasibility of SCC using foundry sand and hybrid fibres[2,5].As the mix design was designed based on finding the optimum percentage of replacement of foundry sand and hybrid fibres based on literature review and development of a suitable mix for SCC using code requirements, that would satisfy the requirements of the plastic state. This offers a unique area of application of self-compacting concrete which can flow through every corner of extensively reinforced area without any vibration and more effective for seismic lo.

This research consists of: (i) finding out the percentage of replacement of optimum percentage of foundry sand and hybrid fibres based on literature review; (ii) development of a suitable mix for SCC that would satisfy the requirements of the plastic state.

1.0 Introduction

Cement-based materials are the most abundant of all man-made materials and are among the most important construction materials, and it is most likely that they will continue to have the same importance in the future. However, these construction and engineering materials must meet new and higher demands. When facing issues of productivity, economy, quality and environment, they have to compete with other construction materials such as plastic, steel and wood. One direction in this evolution is towards self-compacting concrete (SCC), a modified product that, without additional compaction energy, flows and consolidates under the influence of its own weight. The use of SCC offers a more industrialised production. Not only will it reduce the unhealthy tasks for workers, it can also reduce the technical costs of in situ cast concrete constructions, due to improved casting cycle, quality, durability, surface finish and reliability of concrete structures and eliminating some of the potential for human error[3,7]. However, SCC is a sensitive mix, strongly dependent on the

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ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.5, pp 812-819, 2017

Experimental Study on Rice Husk Ash in Concrete by Partial Replacement

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Abstract: This paper describes the experimental study on strength characteristics of M40 grade concrete in which cement is partially replaced by rice husk ash. Rice Husk Ash (RHA) is one of these waste products which are generated as a by-product of rice paddy milling industries. In this study, the strength related properties such as compressive strength, splitting tensile strength, flexural strength were calculated in which concrete specimens produced with 0%, 10%, 12.5% and 15% of the RHA as the cement replacement percentages. Specimens were tested at the ages of 7 and 28 days. Finally, concluded that the RHA replacement level of 12.5% in M40 grade concrete showed higher when compared to other replacement levels.

Keywords: Rice husk ash, Compressive strength, Split tensile strength, Flexural strength.

Introduction:

Concrete is one of the crucial materials for infrastructure development due to its versatile application, globally its usage is second to water. For last few decades, there are many concerns raised for the continuous increase of cement use because of the reasons that the production of cement causes large amount of carbon dioxide (CO_2) emission and it also consume significant amount of natural rock and minerals that may lead to deplete at one point of time. Manufacture of one tonne of Portland cement (PC) generates about one ton of CO_2 to the atmosphere which constitutes 5% global CO_2 emission. To build sustainable environment, it is necessary to control the emission of CO_2. Due to increase in the cost of conventional building materials and environmental hazard, the designers and developers are looking for 'alternative materials' to reduce the use of cement in civil engineering constructions. For this objective, the researchers are trying to use various waste products in concrete technology.

Rice Husk Ash (RHA) is one of these waste products which are generated as a by-product of rice paddy milling industries. For rice growing countries like India, rice husks have attracted more attention due to environmental pollution and an increasing interest in conservation of energy and resources. The concrete industry offers an ideal method to integrate and utilize a number of waste materials, which are socially acceptable, easily available, and economically within the buying powers of an ordinary man. Presence of such materials in cement concrete not only reduces the carbon dioxide Emission, but also imparts significant improvement in workability and durability. Considerable efforts are being taken worldwide to utilize locally available natural waste and by-product materials in making concrete, such as Rice Husk Ash as supplementary cementing materials to improve concrete properties (durability, strength, etc.). The effect of using RHA as a partial

Investigate safety and quality performance at construction site using artificial neural network

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Abstract. Quality inference of a construction project agenda might be an exigent task for project stakeholders. Construction superintendent is decisive to eventual site security performance. In the United States, the OSHA 30-hour training is becoming the de facto standard for supervisor security competency. We concentrate on gap by recognizing the essential knowledge-based security competencies that are most important for the front-line construction supervisor and precedence them for the first time. The intention of the work is to frame an Artificial Neural Network (ANN) with the assist of the optimization techniques. The ANN is utilized to predict the number of rework Work-hrs per $1M in Scope, a number of rework workers (works)-hrs per 200,000 weeks hrs, the number of defects per $1M in Scope and number of defects per 200,000 Work-hr parameters of the construction safety. Different optimization techniques are utilized to discover an optimal weight of the ANN process. All the optimum results demonstrate that the attained error values between the output of the experimental values and the predicted values are closely equal to zero in the designed network. From the results, the minimum error of 89.97% determined by the ANN is attained by the Grey Wolf Optimization (GWO) algorithm.

Keywords: Construction safety, quality, injuries, Artificial Neural Network (ANN), Grey Wolf Optimization (GWO)

1. Introduction

Construction commodity feature could be defined as the degree to which avowed or implied needs and the internal distinctiveness are guaranteed during the progression of construction [1]. Construction contractors have endeavored to execute a choice of safety measures to thwart occupational accidents, together with safety training, site environment management, safety and health management, and opposite health and safety strategy [2]. As for the large-scale construction project, the construction site design setting up with the deliberation of changing site amenities and site space in diverse time intermission phrase as dynamic [3]. The significance of the construction supervisor for appropriate implementation of safety and health programs on construction sites has broadly specified attention revealed that, if safety programs are to be valuable, the psychological environment of workers must be well thought-out [4]. Due to the discrepancy in the construction industry and environment in different countries, there is

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EFFECT OF FLY ASH ON DURABILITY PROPERTIES OF ENGINEERED CEMENTITIOUS COMPOSITES

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ABSTRACT:

The durability characteristics of Engineered cementitious composites (ECC) with various proportions of fly ash are investigated with a view to develop the composites with high resistance to cracks. ECC offers large potential for durable civil infrastructure, due to its high tensile strain capacity and controlled micro- crack width. In this study, the fly ash contents (0.2%, 0.4%,0.6%,0.8%,1% and 1.2%) are varied in the polypropylene fiber reinforced ECC (PFECC) mix are compared with conventional ECC mix reinforced with polyvinyl alcohol fiber (PVA) and durability measures such as rapid chloride penetration test, sorptivity, water absorption, acid attack, sulphate attack are measured. Increasing the fly ash content upto 0.4% improved the durability properties of ECC. The test results indicate that the polypropylene fiber reinforced ECC with varying fly ash content shows better durability performance than the conventional ECC.

Keywords: Engineered cementitious composites, Polypropylene fiber, Durability, Fly ash, Concrete, composites

1.0 Introduction

Concrete is brittle and rigid in nature. This brittleness of concrete increases with increase in compressive strength. High strength concrete possesses high brittleness when compared to concrete of lower strength. For the past few decades, due to the development of high rise buildings, concrete with increasingly high compressive strength is getting used for structural applications[1]. And this leads to development of cracks when high stress concentration occurs in concrete. In order to overcome this, concrete with high tensile strain capacity, known as Engineered cementitious composites (ECC) has been developed.

ECC is a class of the new generation high performance fiber reinforced cementitious composites with high ductility and medium fiber content [2]. ECC exhibits a pseudo strain- hardening behaviour under tensile load by developing micro cracks[3]. Tensile strain capacity of ECC is in the range

Eco. Env. & Cons. 23 (September Suppl.) : 2017; pp. (S57-S63)
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ISSN 0971–765X

Influence of ureolytic bacteria in improving performance characteristics of concrete

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(Received 27 January, 2017; accepted 12 March, 2017)

ABSTRACT

A distinctive strength and durability associated phenomenon in numerous concrete structures are subtle cracks and pores in the concrete. Principally, related cracks and pores result in increasing permeability of cement concrete matrix. Entry of water, atmospheric pollutants and their byproducts can deteriorate the matrix and diminish the strength and durability apparently. Also, it causes corrosion of the installed reinforcement which in turn, enhances the maintenance cost. Previous research works have dealt with conventional repair methods like epoxy injection, latex treatment and provision of further steel in design to limit the crack width within permissible limit. On the other hand, bioconcrete is reliable in enhancing the strength, durability and healing of cracks. In this research the bacterial strain, *Bacillus licheniformis* MTCC 3606, derived from soil is used for calcite precipitation and for achieving better strength and durability properties in hardened concrete. Also, the bacteria was checked for compatibility with different type of superplasticizers. It is inferred from the test results that the compressive and flexural strength got increased significantly. It increased the resistance to acid attack and water absorption in concrete appreciably. SEM analysis has shown the calcite precipitation inside the bacterial concrete. The results obtained from SEM analysis were confirmed by XRD.

Key words : Bioconcrete, Bacillus Lichieniformis MTCC 3606, Calcite precipitation, SEM, XRD.

Introduction

The material which is being used for decades in the field of construction is concrete, is good in compressive strength but is deficient in durability properties like resistance to water absorption, chloride attack, acid attack, and the cracks formed due to drying shrinkage. This leads to damage of the concrete by which, harmful ingredients penetrate through the cracks formed leading to corrosion of incorporated steel in the RCC structures, thereby accelerating the premature loss in structural integrity and the life time of structure. Even though the usage of several cementitious materials like fly ash, GGBS and silica fume have checked the problems of porosity by increasing its density and the problems due to CO_2 emissions while manufacturing the cement up to certain limit, the problems of micro cracks are still in existence and the cost involved in repair works like injecting with epoxy, treating with latex emulsion being carried out to avoid further extension of cracks is higher.

In order to avoid such difficulties, a reliable solution was tried in collaboration with microbiology

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Eco. Env. & Cons. 24 (1) : 2018; pp. (411-416)
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ISSN 0971-765X

Seasonal water quality indexing (WQI) on surface storage and subterranean dispersion at Ukkadam Periyakulam tank in Coimbatore City

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(Received 1 November, 2017; accepted 18 December, 2017)

ABSTRACT

Water quality Indexing helps understand the impulse-response patterns of the water quality parametric changes in relation to the interconnectivity of rainfall-storage-dispersion at any multipurpose tank site. The pre-monsoon, monsoon and the post monsoon fluctuations in the values of water quality index parameters were analyzed in accordance with standard operating procedures.On an invariably uniform gradation range of 1 to 5 weightage, the mean water quality indices were found to be 2.25 to 2.64 for surface water and 2.06 to 2.17 for the ground water, spanning over the seasons. The overall hazard rating could be categorized under medium to high vulnerabilities. By these quality standards, perspective planning to improve upon the water quality in storage as well as under dispersion is to be devised. The prospects of in-situ treatments to control the contamination levels are to be explored through the strategic prospects for dilution by rainwater harvesting and the usage of appropriate filtration system to improvise upon physic-chemical water quality criteria. Eventually, the ecological buffering has been suggested around the tank system to keep off such maladies as eutrophication and deoxegenation resulting from point source and distributed pollution along the contributing system connecting the tank.

Key words : Water Quality Index, eutrophication, deoxegenation, parametric changes, ecological buffering

Introduction

Surface water reserves such as the tanks, ponds, lakes and groundwater aquifers drilled with bore wells and dug wells store the rainwater for the di-versified usage in the proximity viz., irrigation, drinking and industrial water supplies in an inge-nious way of rotational distribution through open channels and pipeline networks (Brown *et al.*, 1970). The urban and suburban pockets of Coimbatore City has been provided with eight PWD controlled system tanks originally intended for catering to the agricultural and allied irrigation needs in their sur-rounds (Vsanthavigar *et al.*, 2010). However, the recent past decades this city has witnessed dras-tic changes by way of extensive urbanization and intensive industrialization coupled with intrusive migrations from rural areas for livelihood (Chang *et al.*, 2010). Consequently, the area under agriculture shrunk paving way for industrial estates, commer-cial complexes and dwelling enclaves thereby esca-lating the water requirements for industrial and do-mestic sectors rather than irrigation (Crossland *et al.*, 1995). Hence the paradigm shift of transforming ag-ricultural requirements of the water towards domes-tic water supplies has become inevitable. Mostly we resort to a conjunctive use of surface and groundwa-ter storage that is also responsible for spatial and over

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Indian Journal of Ecology (2018) 45(2): 384-387

Manuscript Number: 2090
NAAS Rating: 4.96

Water Quality Index Assessment of Domestic Water Supplies in System Tank

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Abstract: The study was confined toa system tank zone of River Noyyal in Coimbatore. The ground water and surface water of the monsoon and post–monsoon seasons were analyzed for various physico-chemical parameters. The Parametric Water Quality values in the respective units of measurement were found to be in the IS permissible ranges prescribed for EC (3to15dS/m), pH(6.2to 6.8), Total dissolved salts (500 to 2000) and sulphates (200 to 400). The overall quality indices for both surface and ground water were arrived at in a gradation system of weightage limits from 1 to 5, as less hazardous to severely hazardous status. The indices established the values in the moderate range of 2.3 to 3.8, suggesting the feasibility of quality sustained domestic water supplies.

Keywords: System Tank, Water Quality Index, Parametric Index, pH, EC, Turbidity, Hardness, Alkalinity, domestic water supplies

Surface water reserves such as the tanks and subterranean aquifers embedded with dug wells and bore wells store the rainwater for the diversified usage in their vicinity viz., irrigation, domestic and industrial water supplies in an ingenious way of roaster based rotational distribution through open channels and pipeline networks (Debels et al 2005,Giridharan et al2010). By and large, the system tanks constructed at various zones of Coimbatore were primarily envisaged to cater to the irrigation needs of agricultural crops in their downstream command areas. However, over the past twenty years this scenario has undergone dramatic changes partly due to extensive urbanization and intensive industrialisation as well. Eventually the agricultural land area has diminished drastically and got converted into real estate pockets. In response to this impulse the agricultural needs also got decreased but the domestic and industrial water requirements got exponentially shotup. Hence the paradigm shift of transforming agricultural requirements of the water towards domestic water supplies has become inevitable. Mostly we resort to a conjunctive use of surface and groundwater storage that is also responsible for spatial and temporal water quality changes in accordance with the contaminant solute transport (Kannel et al 2007, WHO 2008,Sener et al 2017) However, a qualitative scrutiny of the water in storage and that reaching the groundwater aquifers is indispensible. Hence it could be impeccable if the existing water distribution schedule can be modified to suit the dominating domestic water needs compared to the barest minimum agricultural water requirements. By way of incorporating suitable mechanical filtration systems and disinfection schedules assured domestic water supplies at desirable quality level can be accomplished.

Besides, the sustainability of extracting and using both surface and groundwater from the system tank storage and dispersion zone needs extensive investigation. System tanks or non-system tanks do contribute to the aquifer recharge covering a certain radius of influence both on the downstream side and upstream side of storage indicated the well water level fluctuations (Subramani et al 2005) . The present investigation was contemplated to include nodal point water samplings related to the surface storage of water in the tank and well water in the vicinity. Based on these quality indices focused for domestic water supplies, the appropriate filtration and disinfection units can be designed and installed (Horton 1965).

MATERIAL AND METHODS

Study Area: The Noyyal river stretch proliferating and meandering through Coimbatore region encompasses 21 Anaikuts and 31 Tanks, of which 8 system tanks are located within Coimbatore city urban viz.,Narasampathi tank, Krisnampathi tank, Selvampathi tank, Kumarasamy tank, Selvasindhamani tank, UkkadamPeriyakulam tank, Valankulam tank and Singanallur tank. The study was however limited only to UkkadamPeriyakulam tank that is knitted to the downstream reach of the Noyyal River feeding where the concentrated dumping of pollutants and contaminants along the stream flows gushing into the tank

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Indian Journal of Geo Marine Sciences
Vol. 48 (01), May 2019, pp. 772-780

GIS backed parametric surface and groundwater quality indexing in the vicinity of a multi-utility system tank

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Received 09 November 2017; revised 02 May 2018

Parametric water quality indexing (WQI) helps integrate the interwoven effects of independent parameters which may enhance or impair the desirable physico-chemical and biological characteristics of both surface water and groundwater reservoirs. Monsoon and post-monsoon status of the distribution of such parameters will give an insight on improving the

International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 7, Issue 8, August 2018 ISSN 2319 - 4847

PERFORMANCE STUDY OF T - BEAM USING COCONUT SHELL CONCRETE

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Abstract

Coconut shell has been used as coarse aggregate in the production of concrete. This project investigates and evaluates for flexural capacity in T - beams. The flexural behavior of T-beams made with coconut shell is analyzed and compared with the conventional concrete. Four beams of varying reinforcement were cast in both coconut shell concrete and conventional concrete. Totally eight beams were cast and tested for flexural. The beams were loaded on the frame and subjected to loading on two points. This study includes the deflection, cracking, strain and ultimate flexural load. The concrete shell concrete showed increased deflection and earlier cracking. Results also shows that the coconut shell concrete, T-Beam has load bearing capacity comparable to normal conventional concrete by 80 - 85%.

Keywords:Coconut shell concrete, flexural behavior, T-Beam, ultimate flexural load.

1. INTRODUCTION

The reduction in cost of construction is very much needed as the cost of materials are day by day rising up the objective is fulfilled if alternating materials are suggested in place of conventional materials. It is at this time the above approach is logical, worthy and implementable, presently in India, about 960 million tonnes of solid wastes are being generated annually by products during industrial, mining , municipal, agricultural and other processes of these 350 million tonnes are organic wastes from agricultural sources; 290 million tonnes are inorganic wastes of industrial and mining sectors.

2. LIGHT WEIGHT CONCRETE

A concrete whose density lies between 1200 - 1600 kg/m3 as opposed to that of 2400 kg/m3 of normal concrete is known as Light weight concrete. The challenge in making a lightweight concrete is decreasing the density without adversely affecting its strength and maintaining its cost effectiveness. Lightweight concrete is typically made by incorporating natural or synthetic lightweight aggregate or by entraining air into a concrete mixture.

3. OBJECTIVE

- To design and prepare T-Beam using coconut shell concrete.
- To carry out the tests.
- Compare the results with conventional concrete

4. LITERATUREREVIEW

Gunasekaran et al (2013) studied the Plastic shrinkage cracking and deflection characteristics of coconut shell concrete and compared with conventional concrete. Five concrete mixes S1–S5 were considered with different percentage of coconut shell and crushed stone aggregate as coarse aggregate. Forty-five cube (nine cubes for each mixes) and five slabs (one slab for each mix) were tested. Study includes 7, 14 and 28 days density, compressive strength, total plastic shrinkage crack area, and the deflection characteristics. As expected, when the percentage of

International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 7, Issue 8, August 2018 ISSN 2319 - 4847

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Maninder Kaur (2012) the utilization of coconut shell as a coarse aggregate has been discussed based on the results obtained from comprehensive review of literature. The coconut shell is a material which can be a substitute for

« Previous article Next article »

Krill herd-based optimal neural network for analysing safety and quality performance at construction site

Sivasubramanian Balamurugan ⓘ, Mallalan Lenin Sundar ⓘ

Abstract

In construction exertion, an organisation's capacity to convey a quality item in a protected way is the way to business achievement. In order to better comprehend what adds to productive quality and safety programs in construction. The vast majority of the researchers have focused on examining optimisation models to create optimal construction site format offered inspired algorithms. This paper analysed the safety measures in a construction site for high-quality. Here, two distinctive soft computing methodologies are artificial neural network (ANN) and optimisation model. This expectation investigation considers two distinct parameters like reworkers and defects in a construction site. For improving the performance enhance hidden layer and neurons in ANN structure utilising krill herd optimisation strategy so the proposed model as krill heard neural network (KHNN). From this examination, get least mean square error (MSE) and maximum accuracy as 88, 95.26% compared with our existing techniques.

Keywords: construction, safety, neural network, optimisation

PULL OUT BEHAVIOUR OF DEFORMED STEEL BARS IN FLY ASH BLENDED SELF COMPACTING GEOPOLYMER CONCRETE

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This study extends the ongoing investigation on bond performance of embedded steel in self consolidating geopolymer concrete, when Class F fly ash is blended with Class C fly ash. 5% OPC and 10% Class C fly ash are replaced to the basic source material Low calcium Fly ash, to facilitate the external exposure curing conditions and thereby aiming for cast in situ concrete production. Synthesising solutions for source material used are combination of sodium hydroxide and sodium silicates. Normal self compacting concrete, Self compacting geopolymer concrete with added OPC and Self compacting geopolymer concrete with OPC and Class C fly ash are the types of concrete selected for experimental investigation. Pull out tests are carried out by varying diameter and bond length of embedded steel in concrete. Comparison of bond stress on 54 pull out specimens was determined using IS: 2770 (Part 1) and studies revealed that inclusion of Class C fly ash in self consolidating geopolymer improves the bond strength tremendously. Results were compared to the latest empirical models proposed by researchers and FIB model code 2010.

Keywords: Self compacting geopolymer concrete; Ordinary Portland Cement; Class C fly ash; Bond Length; Bond Strength; External exposure curing.

1. Introduction

Geopolymer technologies are widely used in countries like Australia and New Zealand for precast construction, which has proved to be advantageous in terms of sustainability, economy and durability. Inclusion of heat curing methods for enhancing the mechanical properties are major drawback in case of geopolymer concrete and hence developing countries like India, China etc. are not at all interested in acknowledging the current trends. Need for ambient curing thereby emerged in zero cement concepts and different methods were tried to bring down the curing temperature. It was identified that if Calcium oxide content is increased in fly ash precursors, setting time can be decreased without affecting the strength [1]. This can be achieved by introducing supplementary cementitious materials that are rich in calcium oxide content, to the basic source material of geopolymer. Supplimentary cementitious materials like silica fume and metakaolin was added to fly ash which helped in bringing down curing temperature and enhancing mechanical properties [2, 3]. P. Nath and P. K. Sarker investigated on ambient cured geopolymer by introducing Ground blast furnace slag to Class F ash in different proportions to the mix and enhance the early age properties of concrete. Results were compared for the varying proportions of slag and alkaline activator in the mix. Inclusion of slag reduced the setting time and improved the early-age compressive strength significantly [4]. Ambient cured geopolymer was also made out of Ground Blast Furnace Slag and Bottom Ash as source material, which decreased the setting time and improved compression strength appreciably [5].

Geopolymer in Self compacting concrete (SCGC) marked as a milestone in the field of special concretes which helped in fast production of concrete with environment sustainability. Preliminary investigation of SCGC were done using heat curing methods and proved to exhibit outstanding mechanical and microstructural properties [6, 7]. Addition of 10 % Silica fume into low calcium fly ash was seen to improve mechanical properties in elevated curing conditions of 60 degrees [8]. 100% replacement of GGBS to fly ash was also investigated in heat curing regime of 70 degrees and results proved that mechanical properties tend to be reduce in high molarity concentration of sodium hydroxides [9]. Eventhough supplementary cementitious materials are replaced to class F fly ash in SCGC, the need for addition in

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International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 03 - Issue 02(S) || PP.86-94

Concrete Experimental Study on Elastic Constants of Hybrid Geopolymer

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Abstract: In this project low calcium fly ash with GGBS were used as the source material in concrete to fully replace of cement is known as Geopolymer concrete. Additionally Steel, Polypropylene, and coir are incorporated to improve its strength aspects in the concrete are called as hybrid geopolymer concrete at low volume fraction of 0.5. The manufacturing of geopolymer concrete was carried out using the usual concrete technology methods. The silicon and the aluminium are the source material to activate by a combination of sodium hydroxide and sodium silicate solutions to form the geopolymer paste that binds the aggregate sand other un-reacted materials. This paper aims to study about the elastic constants of hybrid geopolymer concrete for the different molarities of NaOH. The molarities of NaOH solution used in this work were 8M, 10M & 12M.

Keywords: Fly ash, GGBS, Geopolymer Concrete, Steel, Polypropylene, coir s, hybrid geopolymer concrete, elastic constants, molarities of NaOH

Introduction

Concrete is conventionally formed by using the ordinary Portland cement as the primary ring binder. Cement developed causes environmental impacts at all stages of the process. The manufacturing of Portland cement releases carbon dioxide (CO_2) that is a significant provider of the greenhouse gas emissions to the atmosphere. The amount of CO_2 emitted by the cement industry is nearly 900 kg of CO_2 for every 1000 kg of cement producedTo reduce the environmental impact of the concrete industry, Mehta (2002) suggests two approaches, a short term and a long term approach. The short term approach would be to practise "industrial ecology" which involves the use of industrial by-products as cement surrogate materials. According to the report of Central Electricity Authority of India (CEA), the total fly ash generation from April 2014 to March 2015 is 184.14 Million Tonnes. The use of Ground Granulated Blast-furnace Slag (GGBS) will increase the strength as well as enhance the mechanical properties of the concrete.

In 1978, Davidovits (1999) projected that binders might be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash and rice husk ash. He termed these binders as geopolymer.

Concrete is the largest part broadly used construction substance in the world due to its high compressive strength, long service life, and low cost. However, concrete has inbuilt disadvantages of low tensile strength and crack resistance. To perk up such weaknesses of the material, numerous studies on reinforced have been performed by Sung Bae Kim et al 2012.

The variation of two or more fibres in the concrete is called as Hybrid Fibre Reinforced Concrete. The function of short-cut fibres as secondary reinforcement in concrete is primarily to reduce crack instigation and transmission (Hsie et al., 2008).

The large and the strong fibres control large cracks. The small and soft fibres control crack initiation and propagation of small cracks (Sivakumar and Santhanam, 2007).

In this experimental work the cement is replaced by low calcium fly ash and Ground Granulated Blast-furnace Slag (GGBS). Low calcium fly ash and GGBS is activated by alkaline activator solution for binding. The bond between the materials in concrete is achieved by the process of polymerization. Additionally s have been added in 0.5% of volume fraction by keeping the steel as permanent and adding other s as partial. The manufacture of hybrid geopolymer concrete (H_yGPC) is carried out using the usual concrete technology methods.

Materials Used:

Fly Ash: Fly ash used in this experimental work was collected from Tuticorin Thermal Power Station located in Tamil Nadu, India. The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 7%lime (CaO) is used.

GGBS: Ground Granulated Blast-Furnace Slag is a waste material generated in iron or slags Industries have significant impact on Strength and Durability of Geopolymer Concrete. It also continues to gain strength over

International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 03 - Issue 02(S) || PP.13-18

Analytical Investigation of Hypothetical Layered Pavement Slab Comprising High Volume Fly Ash Concrete and Fiber Reinforced High Volume Fly Ash Concrete Subjected to Negative Temperature Gradient

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Abstract: In the regions where temperature fluctuations are large ranging from below freezing in winter to high temperatures in summer and also variation of temperature in day and night time presents the impact of daily ambient temperature on the pavement surface heat exchange and subsequent slab temperature stress development Concrete highway pavements fail because of temperature stresses and poor durability rather than lack of strength. Hypothetical Layered pavement technique had been proposed to negotiate the temperature stress and its impact on the warping stresses is studied in this research. Analytical model were created by using software package SAP2000 for negative temperature gradient. Nine types of layered profiles have been modeled and the result are discussed.

Keywords: Temperature stresses, Hypothetical layered pavement technique, High Volume fly ash Concrete, Fiber reinforced High Volume Fly Ash Concrete

I. Introduction

The economic development of the country and the consequent surge in the demand for the transport services and also strategic need of the country necessitated expansion as well as improvement to the road network. India has the second largest network of road. The total length of the road in the country exceeds 3.34 million kilometers

As per present estimate road network carries nearly 65% of freight and 85% of passenger traffic. Traffic on the road is growing at a rate of 10% per annum while the vehicle population is of the order of 12% per annum. The road network developed should centre the needs of increasing traffic and axle loads. This can be achieved by selecting superior material of concrete pavement which can provide strength; enhanced service life and durability, superior material like high Performance concrete selected for the construction of pavement can enhance the service life of the pavement and also reduce maintenance cost. Concrete is a composite material composed of coarse aggregate bonded together with fluid cement that hardens over time. But the production of cement generates large amount of carbon dioxide that contribute to green house effect. Considerable amount of Carbon dioxide could be reduced if the production of cement could be reduced. Concrete is the most versatile and widely used construction material. Normally, conventional concrete is manufactured with Portland cement, which acts as a binder. The production of cement releases considerable amount of CO_2 into the atmosphere and it consumes significant amount of natural resources. In order to reduce this impact, there is a need to develop sustainable alternatives to Portland cement utilizing the industrial by products such as fly ash, ground granulated blast furnace slag, etc. which are pozzolanic in nature.

II. Significance of the Project

[1] To create a Hypothetical analytical model of a layered pavement slab of different coefficient of thermal expansions comprising high volume fly ash concrete(HVFAC) and fibre reinforced high volume fly ash concrete(FRHVFAC)
[2] To investigate the effect of layers on temperature stresses of pavement slab model.
[3] To determine the most effective layer profile in the negotiation of Negative temperature gradient's stresses.

III. Analysis Method

3.1 Finite Element Method

Finite Element Method is defined as a numerical technique for finding approximate solutions to partial differential equations (PDE) and their systems, as well as integral equations. In simple terms, FEM is a method for dividing up a very complicated problem into small elements that can be solved in relation to each other. A rigid pavement is modeled as a slab. Linearly varying Negative temperature gradient is applied as temperature

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International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 03 - Issue 02(S) || PP.60-67

Experimental Study on Light Weight Concrete by Ceramic Waste

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Abstract: This paper investigate the prospect of utilization of the ceramic wastes (CW) such as coarse and fine aggregate in lightweight aggregate concrete (LAC) that is consequence of coarse aggregate material (CAM) substitute with CW and consequence of biscuit substitute fine aggregate material (FAM) on properties of LAC. The composition of ordinary Portland cement (PC): FAM: CAM are 1: 2.21: 3.03 and substituted CAM with CW and FAM with biscuit at the levels of 0, 25, 50, 75 and 100 wt.%. All conditions of LAC was subjected to tested water absorption, thermal conductivity and unit weight at the age of 28 day. The compressive strength at 7, 14, 28 and 56 days was also conducted. The results show that when proportion of CW is increased then density and compressive strength decreased but the water adsorption and thermal conductivity increased. After 28 days, the sample with 100% CW compressive strength and bulk density has reduced from 55.4 to 11.4 MPa and 2394 to 1362 kg/m3. On the other hand 50 wt. % gave the compressive strength and density of 38.1 MPa and 1803 kg/m3 respectively. 50% mix was collected for study with biscuit replaced FAM on mechanical properties. The compressive strength improved when levels of biscuit increased for 50 wt. % were as decreased with excess 50 wt. %. The bulk density and thermal conductivity dropped from 1803 to 1584 kg/m3 and 0.689 to 0.592 W/m°K. The optimum configuration that meet the ASTM C330: standard range for structural lightweight aggregate concrete has t contain 50 wt. % of CW and 100 wt. % of biscuit.

Keywords: lightweight aggregate concrete (LAC), ceramic wastes (CW). Coarse aggregate material (CAM)

I. Introduction

Lightweight concrete (LWC) outlined as a sort of concrete that contains of AN increasing agent that will increase the degree of the mixture that is lighter than the standard concrete.. USA, uk, Sweden, etc has been wide exploitation LWC. The LWC has denseness and thermal conduction. Reduction of load, quicker building rates in construction and lower transport and handling prices square measure blessings of LWC. Light-weight mixture concrete may be shaped employing a vary of light-weight aggregates from natural materials, thermal treatment of natural raw materials, by-products from industrial. Volcanic rock, clay, slate, shale, fly ash, feather palm shell ash, biscuit ceramics, bottom ash etc. were used be light-weight mixture in concrete [1]-[6]. the specified engineering properties of LWC can have a sway on the most effective style of light-weight mixture to use. it's a touch structural, however high thermal insulation properties, square measure required a light-weight, weak mixture may be used. The LAC have AN air dry density not exceptional 2000 kg/m3, however may be as low as four hundred kg/m3 reckoning on the materials used and therefore the compressive strength will vary between one and sixty five MPa [7]. The LAC was usually being designed in accordance with ACI 213R-04 [8].

The environmental problems square measure important and anxious in industrial sector. The small, medium and huge industrials turn out pollution akin to water, air, solid, risky and noise. In ceramic industries, they're the one in all industries that generates solid wastes from method akin to biscuit, deteriorated operating mould etc. The biscuit is defected final product akin to ceramic ware, or unglazed ceramic ware, typically known as terracotta, or, most typically, A negotiator stage in a very glazed final product. The operating moulds square measure drop before expiration or deterioration. From the ministry of business (Thailand) found that the number of deteriorated operating mould is quite 38,000 tons/year [9]. Generally, the management of operating mould waste will utilized in varied manufacture business akin to cement business, the mineral is additional into a clinker concerning 3-5 wt.% of cement weight and created the ceiling that it's utilized in little quantities. Additionally, the ceramic production has broken ceramic wastes concerning five-hitter of ceramic product. Each most operating mould and biscuit square measure drop or land crammed that square measure inappropriate strategies.

It increasing the chance of chemical element compound gas and Causes the worldwide warming. From the property of CW and biscuit that have a lower density than traditional coarse and fine mixture. it's presumably replacement of CAM and FAM This analysis study the optimum quantitative relation of light-

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sciendo DOI: 10.2478/ace-2019-0029 ARCHIVES OF CIVIL ENGINEERING
Vol. LXV ISSUE 2 2019

PERFORMANCE EVALUATION ON SELECTION OF FORMWORK SYSTEMS IN HIGH RISE BUILDINGS USING REGRESSION ANALYSIS AND THEIR IMPACTS ON PROJECT SUCCESS

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The selection of the formwork system for high rise building affects the entire construction project duration and cost. The study reports the factors influencing the selection of different formwork system in the construction of high rise buildings through structural questionnaire survey from the client, contractor, consultant, and interviews with expert members. Total of 40 technical factors was identified from the literature and 220 filled questionnaires were received from the respondent. Relative Importance Index method is used to find the topmost factors affecting the selection of formwork system. Additionally, from factor analysis 22 factors were identified to have a correlation with one another. Regression analysis reveals that duration of the project, maintenance cost, adaptability, and safety have impact on formwork selection across time, cost and quality. These findings could potentially increase the construction company's existing knowledge in relation to formwork selection.

Keywords: Formwork system; Factor analysis; Correlation; Regression analysis.

1. INTRODUCTION

Construction is one of the important sectors in the world. Construction involves huge investment and plays an important role in growth of several other sectors in economy. Globally construction of high rise buildings is increasing in order to save time and space. In construction industry formwork

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PERFORMANCE EVALUATION OF FAULT NODES USING QUEUE THRESHOLD BASED ON N-POLICY PRIORITY QUEUEING MODEL

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***Abstract*—A major issue in Wireless Sensor Networks (WSNs) is the minimum availability of energy and hence reducing the amount of energy consumed is of greater interest. In WSN, large amount of energy is consumed during transmission and failure of nodes in sensor network is common. Here, a novel technique is proposed to reduce the node's energy consumption during data transmission using queue threshold based on N-Policy Priority Queueing Model (PQM) by taking failure of nodes into consideration. A sensor network model is developed analytically to evaluate the performance of the proposed scheme by means of energy consumption and delay by taking node failures into consideration. From the results, it is inferred the average energy consumption savings is about 43% for the optimal threshold value by taking node failures into consideration. Simulations are carried out and the results obtained show that the analytical and simulation results matches thus validating the accuracy of the analytical model.**

Keywords—energy, node failure, N-Policy PQM, queue threshold

I. INTRODUCTION

WSN plays a prominent role in many applications like military and non- military domains [1]. Numerous researches have been carried out in many domains like collaborative data gathering, MAC and routing. Since energy minimization is a key design in most of the research related to WSNs, wide range of algorithms and protocols have been developed. Among many techniques, clustering is also an important technique by which the network lifetime is increased. Many authors have proposed wide range of works related to the formation of cluster and election of Cluster Head (CH) in a cluster. By considering the CHs, the authors in [2] have proposed energy efficient routing to improve the network lifetime.

Sensor networks are classified into homogeneous sensor networks and Heterogeneous Sensor Networks (HSNs). In homogeneous networks, all the nodes will be of same type with reference to hardware and energy [3]. The main problem of using same type of sensor is that the role rotation as CH and the required hardware capabilities and also making the node to act as CHs [4-5]. The other classification, HSNs comprises of two different types of sensor nodes. In most of the research papers, it is inferred that HSNs can improve the network lifetime significantly and also provides better network performance in terms of energy [6].

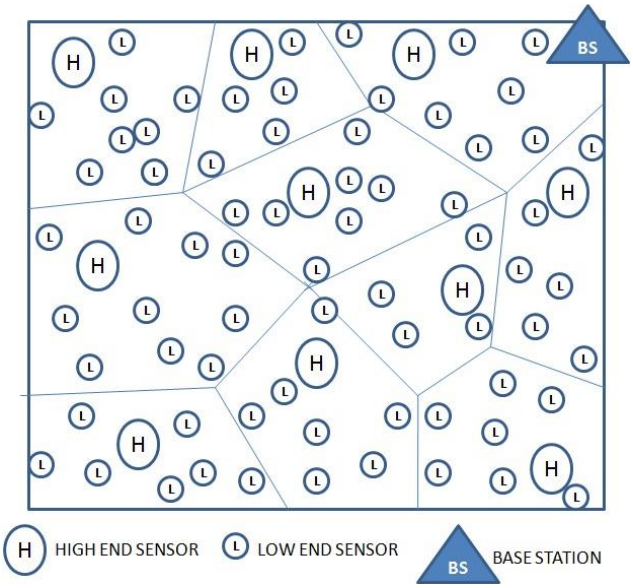

Figure 1 Cluster formations in HSN

In HSN, few high-end sensors (H-sensors) and a more number of low-end sensors (L-sensors) are been distributed uniformly in the field. Clusters are been formed after the deployment process and the H-sensor in each cluster serves as CH as shown in Figure 1. An important energy reduction technique based on queue threshold is an existing model that is widely used technique for delay insensitive WSN applications to increase the network lifetime of HSN [7-14]. Nodes in WSNs are highly prone to be failure due to various reasons like failure due to environmental factors, depletion of energy, failure of hardware, communication link failures, malicious attack, and so on. An HSN model as given in Figure 1 is considered and since node failures are common in a WSN, node failures are considered to study the impact of mean delay with respect to the failures of nodes [7-15]. Here, single L-sensor node's performance is analyzed based on M/D/1 PQM by considering failure of nodes.

In this paper, a HSN is considered where clustering is performed as shown in figure 1. In each cluster, H-sensor act as CH and L-sensors act as Cluster Member (CM). Here, an

analytical model of a cluster oriented HSN is developed using queue threshold based on M/D/1 PQM by considering failure of nodes. The performance of the proposed technique by means of energy consumption and delay is analysed by taking node failures into consideration. The organization of the paper is structured as follows. Section II describes the system model. Section III provides the performance analysis and numerical equations and solutions for determining the delay, energy and the optimum queue threshold value (N*) based on M/D/1 PQM by considering node failure. Section IV provides the simulation model and section V describes the results and discussion. Conclusion is presented in section VI.

II. SYSTEM MODEL

In HSN, a single cluster represented in figure 2 is considered. In this cluster, depending upon the criticality of the packet, packet is classified into High Priority (HP) or Low Priority (LP) packet. No threshold condition (N=1) is considered for HP packets, since the HP packets need to be serviced immediately but the NPM is considered for LP packets since it can manage some delay. The sensor node will transit from IDLE state to BUSY state immediately if it receives a HP packet and it will wait for N packets to move from IDLE state to BUSY and actual data transfer takes place during the BUSY state. If any fault occurs during BUSY state, then the transmission is stopped and the fault at the node is detected [12 & 16]. Once after the faulty node recovers, the packet transmission is continued in the BUSY state. The following assumptions are made for analysis:

- All L-sensor and H-sensor nodes in a HSN are identical
- The arrival rate follows Poisson process with mean arrival rate per node (λ)
- λ_1 and $\lambda_2$are the arrival rate of LP and HP packets where $\lambda = \lambda_1 + \lambda_2$
- Delivery of Packets is with mean service time ($1/\mu$)
- Failure rate is assumed to follow Poisson process with mean $1/\alpha$ and mean repair time $1/\beta$
- Whenever the sensor node switches from sleep to active state, the buffer is assumed to be empty

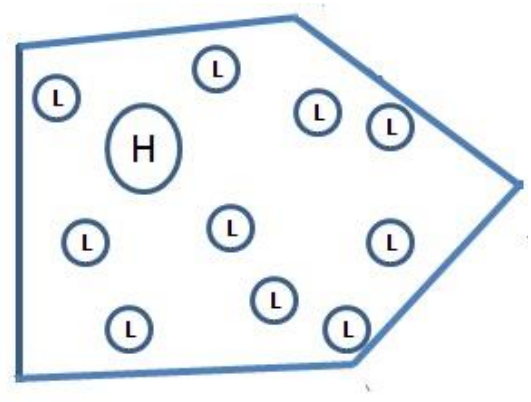

Figure 2 A cluster in HSN

III. PERFORMANCE ANALYSIS

The behavior of a single L-sensor in a cluster is analyzed in this section by taking considering failure of nodes using M/D/1 PQM and the performance of the system is analyzed in terms of the following parameters.

A. Mean delay

Mean delay in an L-sensor node is defined as the mean waiting time of the packets in the queue. Considering an M/D/1 PQM, the average number of LP and HP in the queue (L_1 and L_2) is given by

$$L_1 = \rho_{br1} + \frac{N-1}{2} + \frac{\alpha\lambda_1\rho_1}{2\beta^2(1-\rho_{br1})} + \frac{\rho_{br1}^2}{2(1-\rho_{br1})} \quad (1)$$

$$L_2 = \rho_{br2} + \frac{\alpha\lambda_2\rho_2}{2\beta^2(1-\rho_{br2})} + \frac{\rho_{br2}^2}{2(1-\rho_{br2})} \quad (2)$$

Where

$$\rho_{br1} = \rho_1\left(1+\frac{\alpha}{\beta}\right)$$

$$\rho_{br2} = \rho_2\left(1+\frac{\alpha}{\beta}\right)$$

$$\rho_1 = \frac{\lambda_1}{\mu}\ ,\ \rho_2 = \frac{\lambda_2}{\mu}$$

The mean waiting time of the LP & HP packets in the queue (W_{q1} & W_{q2}) is given by,

$$W_{q1} = \frac{L_1}{\lambda_1} - \frac{1}{\mu} \quad (3)$$

$$W_{q2} = \frac{L_2}{\lambda_2} - \frac{1}{\mu} \quad (4)$$

B. Average energy consumption of an L-sensor node

The average energy consumption of LP and HP in L-sensor node $E_1(N)$ & $E_2(N)$ can be expressed as

$$E_1(N) = C_H(L_1) + C_T(\mathrm{Ncy}_1) \quad (5)$$

$$E_2(N) = C_H(L_2) + C_T(\mathrm{Ncy}_2) \quad (6)$$

Where

$$Ncy_1 = \left(\frac{\lambda_1(1-\rho_{br1})}{N}\right)$$

$$Ncy_2 = \lambda_2(1-\rho_{br2})$$

The average energy consumption is given by

$$E(N) = E_1(N) + E_2(N) \quad (7)$$

C. Optimal threshold value (N^*) of N

The value of N for which the sensor node consumes lowest amount of energy is the optimal threshold value (N^*) is and it is given by

$$N^* = 0.5\left[\sqrt{\frac{8C_T\lambda_1(1-\rho_{br1})}{C_H}+1}-1\right] \quad (8)$$

IV. SIMULATION MODEL

In this section, the simulation model is presented. Simulations are performed by considering Mica2 for a cluster based HSN as mentioned in tables 1 and 2.

TABLE 1 CLUSTER SPECIFICATIONS

Mean arrival rate per node (packets/sec)	2 to 20
Probability of HP packets (p)	0.1 to 0.5
Mean service time per packet (msec)	15
Number of L-sensor per cluster	10
Number of H-sensor in HSN	10
Number of clusters in a HSN	10
Threshold value	1 to 20
Failure rate (α)	0.01
Mean repair time (β) (seconds)	0.01
Battery (V)	3
Data rate (Kbaud)	38.4
Preamble length (bytes)	271
Packet length (bytes)	36
Radio off (μA)	20

TABLE 2 TIME AND CURRENT SPECIFICATION

Operation	Time (sec)	I (mA)
Initialize radio	350E-6	6
Turn on radio	1.5E-3	1
Switch to Tx mode	250E-6	15
Tx 1 byte	416E-6	20

The C_T and C_H values are determined as 6.9 mJ and 0.8 mJ respectively [17] and it is assumed failure rate α = 0.01 and mean repair time and β = 0.01 sec [18]. Various results are obtained by changing the threshold value and mean arrival rate per node with p=0.2 in order to determine the mean delay, average number of cycles/second and average energy consumption of an L-sensor node in a cluster by considering without and with failure in PQM. It is inferred from the simulation results show that the average number of cycles is less and the average energy consumption is high in with node failure when compared to without node failure but the mean delay is high in with node failure when compared to without node failure. Also, minimal amount of energy is consumed by the node for optimal threshold value N^*. It is observed that the (%) saving in energy consumption is reduced in with node failure in PQM when compared to NPM for the optimal threshold value (N*).

V. RESULTS AND DISCUSSION

Simulation and analytical results are shown in this section. The results are obtained by changing the threshold value and mean arrival rate per node to determine the mean delay, average number of cycles and energy consumption of an L-sensor node with and without node failure in PQM. The mean arrival rate per node is taken as 5 packets/sec and the mean delay, the average number of cycles/second and average energy consumption for with and without node failure in PQM is determined.

TABLE 3 ARRIVAL RATE VS MEAN DELAY

Arrival rate (λ)	Mean delay (msec)	
	Without node failure	With node failure
5	0.114	797
10	0.229	1629

From the table 3, simulation results show that the mean delay is very high in when node failure is considered when compared to without failure case in PQM for mean arrival rate per node as 5 and 10 packets/sec, p=0.2, α=0.01 and β = 0.01 sec. The reason is that the packets have to wait for more period of time until the node recovers from failure.

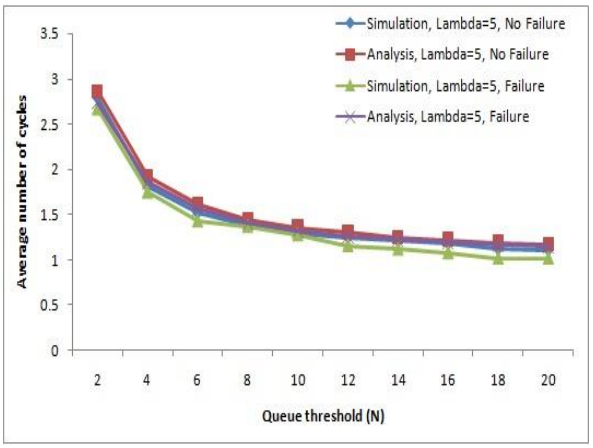

Figure 3 Queue threshold (N) vs Average number of cycles

From figure 3, it is observed that the average number of cycles reduces as the value of N increases. Here, the switching from IDLE state to BUSY state and vice versa in an L-sensor node is less when the queue threshold (N) is high because the time consumed for the buffer to be filled with threshold number of packets for high value of N is more when compared to that for a low value of N. Hence the average number of cycles is reduced when N increases. Also from Figure 3, the average number of cycles is less in node failure case when compared to without node failure case because more packets will be

accommodated during each cycle when the node is in IDLE state.

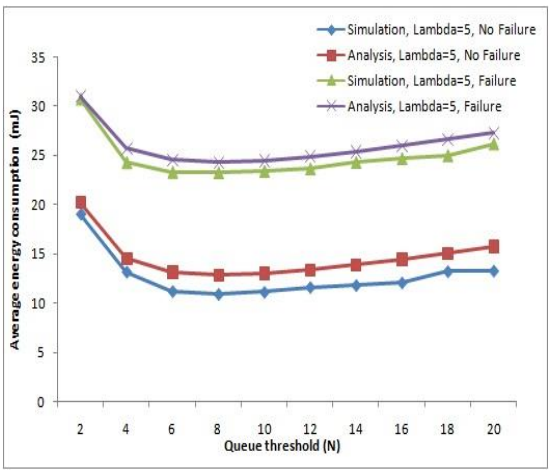

Figure 4 Queue threshold (N) vs Average energy consumption (mJ) showing minimum energy consumption at optimal threshold

The average energy consumption is determined for various values of N by assuming the mean arrival rate per node as 5 by considering node failure rate α=0.01 and mean repair time β = 0.01 sec and it is shown in figure 4. From Figure 4, it is inferred that, the energy consumption per node decreases and increases and minimum energy is utilized for the optimal threshold as N increases. The average energy consumption per node decreases when N increases because, as N increases, the number of cycles per second decreases resulting in less energy consumption. The average energy consumption per node increases as N increases because, as N increases, the number of cycles per second decreases but increases the average number of packets in the buffer resulting in more energy consumption.

It is also inferred from the figure 4 that the average energy consumption is more in node failure case when compared to without node failure case because of the more number of packets accumulated in the queue which increases the transmission energy cost. From Figure 4, by taking node failure into account, the average energy consumption per node in L sensor is minimum at optimal threshold $N^* = 8$. By considering $\lambda = 5$, α=0.01 and mean repair time $\beta = 0.01$ sec, C_T and C_H values as mentioned in section 4, the optimal threshold value (N^*) using equation (8) is determined as $N^* = 8$.

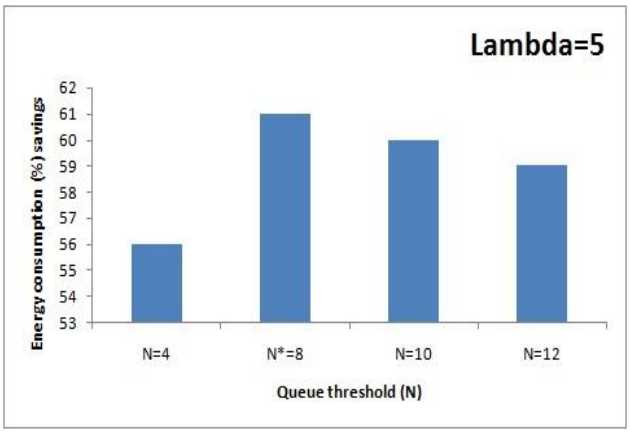

Figure 5 Queue threshold (N) vs Energy consumption savings (%) – without node failure

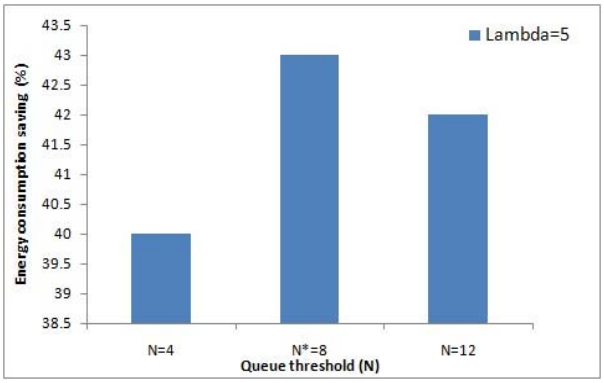

Figure 6 Queue threshold (N) vs Energy consumption savings (%) – with node failure

Figure 5 and 6 shows the energy consumption savings (%) for various values of N by considering without and with node failure. By assuming N = 4, N* = 8, and N = 12, and mean arrival rate per node = 5 packets/sec, the energy consumption savings (%) is determined and it is found to be 40%, 43%, and 42% respectively when compared to no threshold condition (i.e., N = 1). It is also inferred from Figure 5 and 6 that the (%) saving in energy consumption is less in node failure case when compared to without node failure case.

V. CONCLUSION

This paper proposes energy minimization scheme which reduces the average energy consumption of individual nodes in the cluster based HSN based on M/D/1 PQM in order to improve the network lifetime of the HSN by considering node failure. The expression for the optimal value of queue threshold for which the node consumes minimum energy using PQM under node failure case is also derived. Results obtained show that the mean delay increases due to node failure and the average energy consumption increases due to accumulation of more packets during node failure and recovery period. Also, the maximum (%) consumption savings is obtained at optimal threshold and the trade-off that exist between the mean delay and average energy consumption is explored. Simulations are performed and the results obtained show that the simulation results and the analytical results matches thus validating the accuracy of the approach.

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Opt Quant Electron (2018) 50:222
https://doi.org/10.1007/s11082-018-1487-z

Photonic crystal with epsilon negative and double negative materials as an optical sensor

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Received: 7 November 2017 / Accepted: 29 April 2018

Abstract Two ternary photonic crystals are proposed for sensing applications. The first one is composed of an air layer as an analyte sandwiched between two double negative material (DNM) layers whereas the second one consists of an air layer sandwiched between two epsilon negative material (ENM) layers. The transmission spectrum is studied for two different values of the refractive index of the analyte layer with $\Delta n = 0.01$. A specific peak in the transmission spectrum is observed and the wavelength at which the peak occurs is determined. The wavelength shift due to any change in the index of the analyte layer is also determined. The effect of varying the parameters of the DNM and ENM on the sensitivity of the sensor is discussed. It is found that the sensitivity of the structure ENM/air/ENM is much greater than that of the structure DNM/air/DNM and it is estimated as 26 times of the sensitivity of the latter structure.

Keywords Photonic crystal · Epsilon negative materials · Double negative materials · Sensor

1 Introduction

Photonic crystals have received an increasing interest due to the exceptional properties they exhibit when electromagnetic waves are propagating through them (Sandhu et al. 2006; Kriegel and Scotognella 2015; Zare and Gharaati 2014). The unique property of the

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Published online: 11 May 2018

photonic crystal is the appearance of a band gap in a specific frequency range in which the propagation of waves is not allowed (Wu et al. 2010; Awasthi et al. 2006). The width of the band gap is determined by the lattice constant and the wavelength of the propagating electromagnetic wave and its origin can be attributed to Bragg scattering in periodic multilayer structures. Bragg band gaps rely on the wave angle of incidence and the light polarization. Photonic band gap structures have been proposed for a set of applications such as optical sensors (Banerjee 2009a; Taya et al. 2017a), omnidirectional reflectors (Awasthi et al. 2006), filters (Awasthi and Ojha 2008) and temperature sensors (Banerjee 2009b). They can also be used in the study of optical properties of nanocomposites (Ramanujam and Joseph Wilson 2016).

Optical sensors are self-contained integrated devices from which we can obtain diagnostic facts about the existence of biological objects or the presence of any pollution in an analyte (Taya 2014, 2015a, b, c; Taya and Alamassi 2015; Tiefenthaler and Lukosz 1989; Taya et al. 2016, 2017b). They can be used in environmental monitoring, the pharmaceutical industry, and food technology (Taya and El-Agez 2011a, b; Taya et al. 2012a; Horvath et al. 2003; El-Agez and Taya 2011; Kullab and Taya 2014; Taya and Kullab 2014). They can be utilized to detect biological molecules in the size range from nanometers to micrometers. In Tiefenthaler and Lukosz (1989) proposed for the first time, a slab waveguide as an optical sensor. They employed it as a gas senor. They detected a small change in index of refraction of the gas is measuring the change in the effective index of refraction. The great concern in slab waveguide sensors can be observed in the tremendous number of papers and review articles published in many journals (Singh and Kumar 2009; Kullab et al. 2012, 2015; Kuswandi 2003; Taya and El-Agez 2012a, b; Udd 1995; Kullab and Taya 2013). Cylindrical fibers were also proposed as biosensors such as enzyme optical fiber based biosensors (Kuswandi 2003). Recently, surface plasmon resonance based waveguides have become very popular for measuring bimolecular interactions (Homola et al. 1999). Metal clad waveguide was also proposed as an optical sensor to detect biological objects in the size of micrometer (Kullab and Taya 2014; Taya and Kullab 2014). Significant efforts have been done to develop optical waveguide sensors for biological and bio-chemical purposes. Making use of thin high contrast refractive index media, it was demonstrated that simple silicon-on-insulation photonic wire based technique offer improved sensitivity to surface adsorption when compared to evanescent wave sensors (Densmore et al. 2006). The improved sensitivity can be attributed to the high and localized electric field in the analyte layer. The penetration depth of such waveguides can reach more than 200 nm.

In Veselago (1968) was the first who proposed a material with simultaneously negative ε and μ. They were referred to as double-negative materials (DNM) or left-handed materials (LHM). Traditional materials have both ε and μ positive and are called double positive materials (DPM). In contrast, metamaterials are classified into double negative materials (DNM) when both ε and μ are negative, epsilon negative materials (ENM) when only ε is negative and mu negative materials (MNM) when only μ is negative. DNMs exhibit a peculiar property of antiparallel nature of wave and Poynting vectors. These materials do not exist in nature but are man-made. Recently, DNM as a new man-made composite metamaterial has received an enormous interest by researchers in physics and engineering due to its wide range of applications (Shelby et al. 2001; Taya et al. 2012b, 2013a; Taya and Qadoura 2013; Pendry et al. 1996). DNMs can find interesting applications in optoelectronics, electromagnetic theory, optical sensing, material science and solid-state physics. They have many upnormal properties different from positive-index materials such as negative refractive index. Several theoretical and experimental studies (Pendry et al. 1999; Taya et al. 2013a; Abadla and Taya 2014; Taya and Elwasife 2014) were conducted

to understand the behavior of electromagnetic waves in such media and find proper applications such as DNM antennas, stealth effect, and cavity resonator.

In this work, two ternary photonic crystals are proposed as sensors for refractometric applications. The first one has the structure DNM/air/DNM whereas the second one has the structure ENM/air/ENM. The transmission spectra from these two structures are studied for two different values of air refractive index. The wavelength at which the first peak occurs is observed and its shift due to the variation of the analyte index of refraction is recorded. The effect of different parameters of the DNM and ENM on this shift is also studied.

2 Theory

Theory of transmission from photonic crystals either binary or ternary can be treated using transfer matrix method. When an s-polarized wave is an incident on a single layer, it is partially reflected and transmitted. The transfer matrix that relates the incoming and outgoing fields to each other is called the characteristic matrix and is given by

$$\mathrm{M_i} = \begin{pmatrix} \cos\delta_\mathrm{i} & -\frac{\mathrm{i}}{\mathrm{P_i}}\sin\delta_\mathrm{i} \\ -\mathrm{ip_i}\sin\delta_\mathrm{i} & \cos\delta_\mathrm{i} \end{pmatrix} \tag{1}$$

where $\delta_\mathrm{i} = \frac{\omega}{\mathrm{c}}\mathrm{n_i d_i}\cos\theta_\mathrm{i}$, ω is the angular frequency ($\omega = \frac{2\pi \mathrm{c}}{\lambda}$), c is the speed of light in vacuum, λ is the wavelength of the incident wave, $\mathrm{d_i}$ is the thickness of the layer i, $\mathrm{n_i}$ is the index of refraction of layer i, θ_i is the angle of incidence in layer i, $\mathrm{p_i} = \sqrt{\varepsilon_\mathrm{i}/\mu_\mathrm{i}}\cos\theta_\mathrm{i}$, ε_i and μ_i are the permittivity and permeability of layer i.

The angle of incidence inside layer i (θ_i) can be related to the angle of incidence (θ_o) through the relation

$$\cos\theta_\mathrm{i} = \left[1 - \frac{\mathrm{n_i^2}\sin^2\theta_\mathrm{o}}{\mathrm{n_o^2}}\right]^{1/2} \tag{2}$$

The index of refraction of any layer can be calculated in terms of the permittivity and permeability as $\mathrm{n_i} = \sqrt{\varepsilon_\mathrm{i}\mu_\mathrm{i}}$ for a material with positive parameters and $\mathrm{n_i} = \sqrt{\varepsilon_\mathrm{i}\mu_\mathrm{i}}$ for a material with negative parameters.

For a one period consisting of three layers, the characteristic matrix is given by

$$\mathrm{S_i} = \prod_{i=1}^{3}\begin{pmatrix} \cos\delta_\mathrm{i} & -\frac{\mathrm{i}}{\mathrm{P_i}}\sin\delta_\mathrm{i} \\ -\mathrm{ip_i}\sin\delta_\mathrm{i} & \cos\delta_\mathrm{i} \end{pmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}, \tag{3}$$

where

$$S_{11} = \left(\cos\delta_1\cos\delta_2\cos\delta_3 - \frac{p_2\sin\delta_1\sin\delta_2\cos\delta_3}{p_1} - \frac{p_3\cos\delta_1\sin\delta_2\sin\delta_3}{p_2} - \frac{p_3\sin\delta_1\cos\delta_2\sin\delta_3}{p_1}\right) \tag{4}$$

$$S_{12} = -i\left(\frac{\sin\delta_1\cos\delta_2\cos\delta_3}{p_1} + \frac{\cos\delta_1\sin\delta_2\cos\delta_3}{p_2} + \frac{\cos\delta_1\cos\delta_2\sin\delta_3}{p_3} - \frac{p_2\sin\delta_1\sin\delta_2\sin\delta_3}{p_1p_2}\right) \tag{5}$$

$$S_{21} = -i\Big(p_1 \sin\delta_1 \cos\delta_2 \cos\delta_3 + p_2 \cos\delta_1 \sin\delta_2 \cos\delta_3 + p_3 \cos\delta_1 \cos\delta_2 \sin\delta_3 - \frac{p_1 p_3 \sin\delta_1 \sin\delta_2 \sin\delta_3}{p_2}\Big), \tag{6}$$

$$S_{22} = \left(\cos\delta_1 \cos\delta_2 \cos\delta_3 - \frac{p_1 \sin\delta_1 \sin\delta_2 \cos\delta_3}{p_2} - \frac{p_2 \cos\delta_1 \sin\delta_2 \sin\delta_3}{p_3} - \frac{p_1 \sin\delta_1 \cos\delta_2 \sin\delta_3}{p_3}\right). \tag{7}$$

The total transfer matrix of a ternary photonic crystal having N periods and each period comprising three layers can be written as

$$\mathrm{L} = \prod_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{S_i} \tag{8}$$

The transmission coefficient for the proposed photonic crystal can be written as

$$\mathrm{t} = \frac{4}{\left(\mathrm{L}_{11} + \mathrm{L}_{22}\right)^2 + \left(\mathrm{L}_{12} + \mathrm{L}_{21}\right)^2} \tag{9}$$

where $\mathrm{L_{ij}}$ are the elements of the matrix L.

According to Lorentz model, the permittivity and permeability of a double-negative material (El-Agez and Taya 2011) is given by

$$\varepsilon_{\mathrm{r}} = \varepsilon_{\mathrm{a}} + \frac{\omega_{\mathrm{pe}}^2}{\omega_{\mathrm{e}}^2 - \omega^2 + \mathrm{j}\omega\gamma_{\mathrm{e}}} \tag{10}$$

$$\mu_{\mathrm{r}} = \mu_{\mathrm{a}} + \frac{\omega_{\mathrm{pm}}^2}{\omega_{\mathrm{m}}^2 - \omega^2 + j\omega\gamma_{\mathrm{m}}} \tag{11}$$

where ε_{r} and μ_{r} are the relative permittivity and permeability, ω_{pe} and ω_{pm} denote the electric and magnetic plasma frequency, ω_{e} and ω_{m} denote the electric and magnetic resonance frequency and γ_{e} and γ_{m} are the electric and magnetic damping coefficients. For a negative epsilon material, they are given by

$$\varepsilon_{\mathrm{r}} = \varepsilon_{\mathrm{a}} + \frac{\omega_{\mathrm{pe}}^2}{\omega_{\mathrm{e}}^2 - \omega^2 + j\omega\gamma_{\mathrm{e}}} \tag{12}$$

and $\mu_{\mathrm{r}} = \mu_{\mathrm{a}}$.

3 Results and discussion

Two different ternary photonic crystals were assumed with the structures DNM/air/DNM and ENM/air/ENM. Figures 2, 3, 4, 5 and 8 correspond to the structure DNM/air/DMN whereas Figs. 6 and 7 correspond to the structure ENM/air/ENM. A photonic crystal with N = 16 periods was considered with each period having three layers. The layer thicknesses

were taken as $d_1 = 12$ mm, $d_2 = 6$ mm and $d_3 = 12$ mm. The electric and magnetic damping coefficients were neglected, i.e., $\gamma_e = \gamma_m = 0$ so that we don't have loss or absorption. Other parameters were taken as $\omega_{pe} = \omega_{pm} = 2\pi \times 10$ GHz and $\frac{\omega_{pe}}{\omega_e} = \frac{\omega_{pm}}{\omega_m} = 10$.

We first show the dispersion of permittivity and permeability of the DMN to find out the region in which the two functions are negative. Figure 1 shows ε_r and μ_r of the DNM as functions of frequency of the incident wave. It is clear that in the frequency range $1\ \text{GHz} \le \omega \le 12\ \text{GHz}$, both ε_r and μ_r are negative. We will restrict ourselves to this region to make sure that we work in the negative region.

In each of the following figures, we plot the transmission versus frequency of the incident wave for two values of the index ($n_2 = 1.00$ and $n_2 = 1.01$) of the analyte (air) layer with $\Delta n_2 = 0.01$. We consider the first peak in the transmission spectrum for the two values of the index of refraction of the air layer and observe the shift in the frequency due to the change in the air index. The wavelength shift $\Delta\lambda$ can be calculated from the frequency shift. The sensitivity of the proposed sensor can be viewed through the value of $\Delta\lambda$. The higher $\Delta\lambda$ is, the higher the sensitivity of the sensor.

In Fig. 2, the transmittance profile is shown for $\varepsilon_a = 1.21$ and $\mu_a = 1.2$. The solid line stands for $n_2 = 1.00$ whereas the dashed line stands for $n_2 = 1.01$. The figure inset shows an enlarged view of the first peak for both values of n_2. There is an obvious shift of the frequency at which the first peak occurs. For a refractive index change of $\Delta n = 0.01$, the shift in the wavelength is about $\Delta\lambda = 5.064$ μm which is a good shift that can be detected with recent optoelectronic devices. In Fig. 3, the transmittance versus frequency is displayed for different values of μ_a with $\mu_a = 1.20$, 1.25, 1.30 and 1.35. As can be seen from the figure, the wavelength shifts corresponding to $\Delta n = 0.01$ are 5.064, 5.124, 5.185 and 5.247 for $\mu_a = 1.20$, 1.25, 1.30 and 1.35, respectively. This means an enhancement of the sensitivity can be obtained with the increase of μ_a. If μ_a is kept constant and ε_a is changed to have the values 1.31, 1.41, 1.51 and 1.61 as shown in Fig. 4, the shift becomes $\Delta\lambda = 5.467$, 5.686, 5.708 and 5.927, respectively, for the same change in the analyte refractive index. When the value of either ε_a or μ_a is enhanced, the sensitivity can be improved.

We now turn our attention to electric plasma frequency (ω_{pe}) and electric resonance frequency (ω_e) to find out the effect of changing the ratio ω_{pe}/ω_e on the sensitivity. In

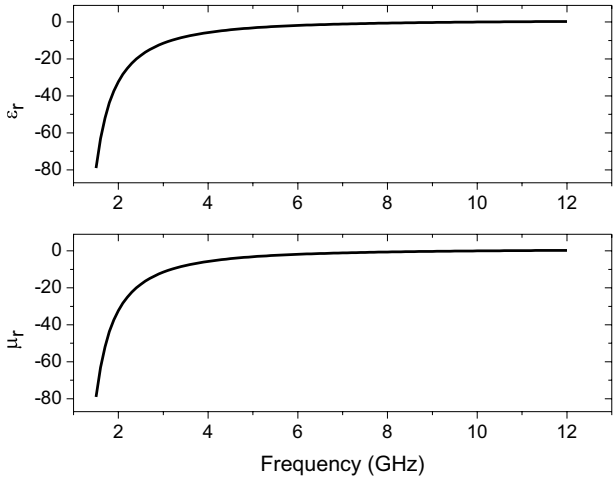

Fig. 1 ε_r and μ_r versus frequency for the DNM for $\varepsilon_a = 1.21$, $\mu_a = 1.2$, $\omega_{pe} = \omega_{pm} = 2\pi \times 10$ GHz, $\gamma_e = \gamma_m = 0$ and $\frac{\omega_{pe}}{\omega_e} = \frac{\omega_{pm}}{\omega_m} = 10$

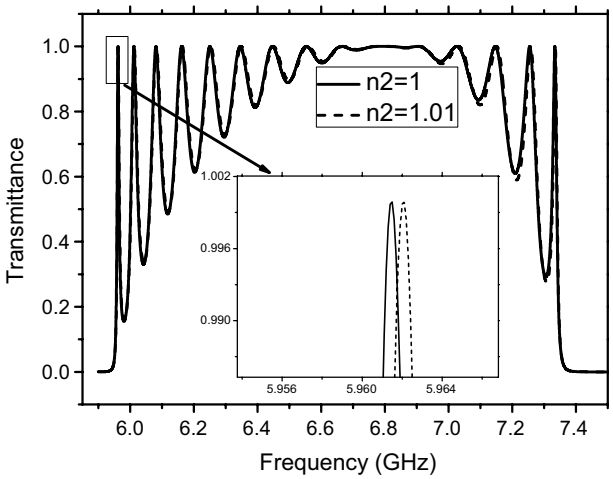

Fig. 2 Transmittance versus frequency for the ternary photonic crystal consisting of DNM/air/DNM for different values of n_2 for $N=16$, $d_1=12$ mm, $d_2=6$ mm, $d_3=12$ mm, $\varepsilon_a=1.21$, $\mu_a=1.2$, $\omega_{pe}=\omega_{pm}=2\pi\times 10$ GHz, $\gamma_e=\gamma_m=0$ and $\frac{\omega_{pe}}{\omega_e}=\frac{\omega_{pm}}{\omega_m}=10$

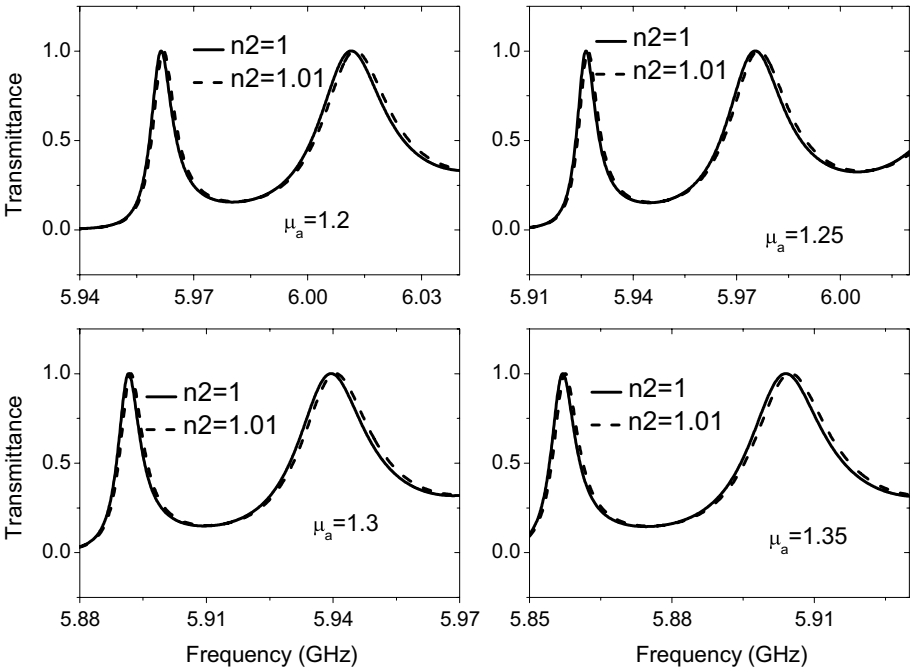

Fig. 3 Transmittance versus frequency for the ternary photonic crystal consisting of DNM/air/DNM for different values of n_2 for $N=16$, $d_1=12$ mm, $d_2=6$ mm, $d_3=12$ mm, $\varepsilon_a=1.21$, $\omega_{pe}=\omega_{pm}=2\pi\times 10$ GHz, $\gamma_e=\gamma_m=0$ and $\frac{\omega_{pe}}{\omega_e}=\frac{\omega_{pm}}{\omega_m}=10$. The figure is plotted for different values of μ_a

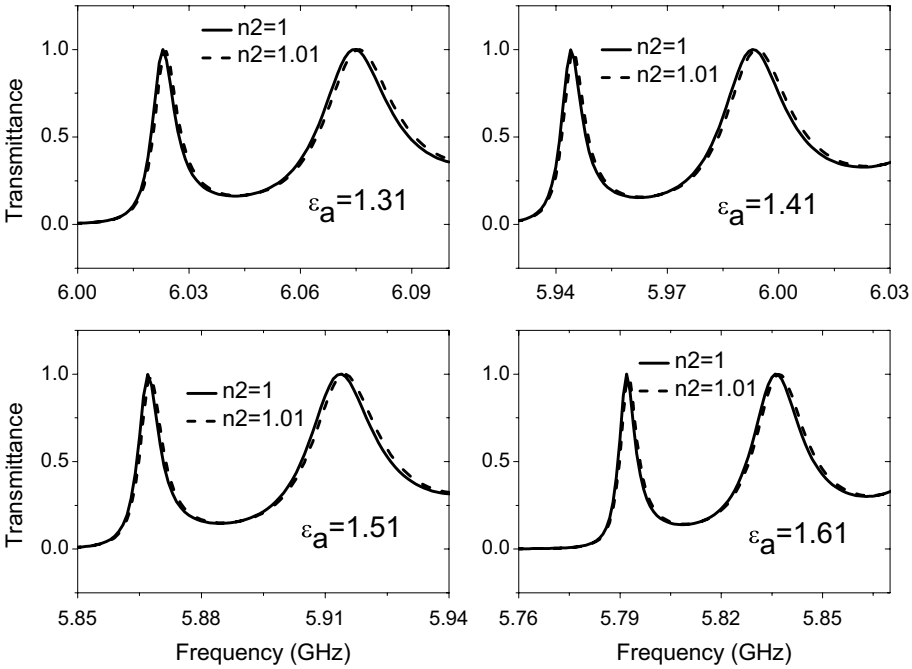

Fig. 4 Transmittance versus frequency for the ternary photonic crystal consisting of DNM/air/DNM for different values of n_2 for $N=16$, $d_1=12$ mm, $d_2=6$ mm, $d_3=12$ mm, $\mu_a=1.2$, $\omega_{pe}=\omega_{pm}=2\pi\times 10$ GHz, $\gamma_e=\gamma_m=0$ and $\frac{\omega_{pe}}{\omega_e}=\frac{\omega_{pm}}{\omega_m}=10$. The figure is plotted for different values of ε_a

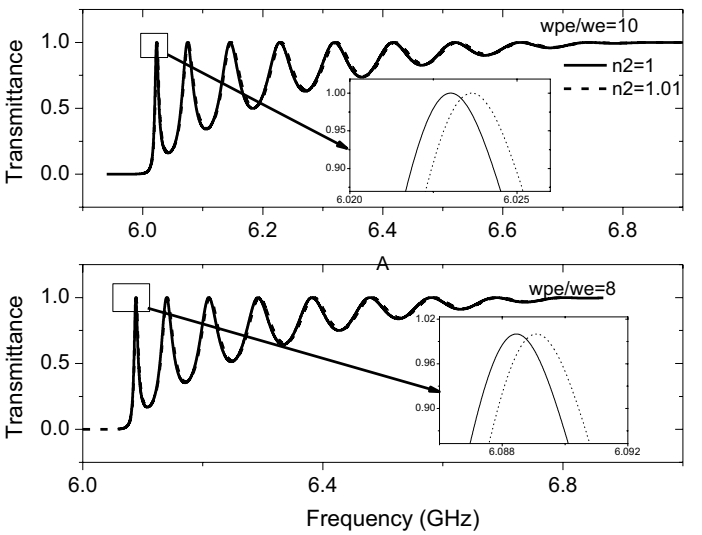

Fig. 5 Transmittance versus frequency for the ternary photonic crystal consisting of DNM/air/DNM for different values of n_2 for $N=16$, $d_1=12$ mm, $d_2=6$ mm, $d_3=12$ mm, $\varepsilon_a=1.31$, $\mu_a=1.2$, $\omega_{pe}=\omega_{pm}=2\pi\times 10$ GHz, and $\gamma_e=\gamma_m=0$. The figure is plotted for two values of ω_{pe}/ω_e

Fig. 5, the transmittance versus frequency is shown for two values of ω_{pe}/ω_e. In the upper and lower panels, the ratio ω_{pe}/ω_e was chosen to have the values 10 and 8, respectively. As can be seen from the figure, for $\frac{\omega_{pe}}{\omega_e} = 10$, the wavelength shift is $\Delta\lambda = 5.467$ but for $\frac{\omega_{pe}}{\omega_e} = 8$, this shift was obtained as $\Delta\lambda = 5.179$. It is clear that as the ratio ω_{pe}/ω_e increases the sensitivity can be enhanced.

We now change the structure to check a photonic crystal with two negative epsilon material layers. The transmittance versus frequency for a structure consisting of an air layer sandwiched between two ENM layers is illustrated in Fig. 6 for two different values of n_2 with $\Delta n = 0.01$. The parameters were taken as $\varepsilon_a = 1.21$, $\mu_a = 1$ and $\omega_{pe} = \omega_{pm} = 2\pi \times 10$ GHz. The solid line stands for $n_2 = 1.00$ whereas the dashed line stands for $n_2 = 1.01$. There is a huge frequency shift due to the change in the refractive index of the analyte layer. The wavelength shift was found to be $\Delta\lambda = 129.1$ μm. Compared to the structure DNM/air/DNM, the sensitivity of the structure ENM/air/ENM is much greater and is estimated as 26 times of the sensitivity of the former structure. In a similar manner to Fig. 5, the sensitivity of the structure ENM/air/ENM can be slightly enhanced with the increase of the ratio ω_{pe}/ω_e as can be seen in Fig. 7. The wavelength shift was found $\Delta\lambda = 129.1$ μm for $\frac{\omega_{pe}}{\omega_e} = 10$ and $\Delta\lambda = 128.2$ for $\frac{\omega_{pe}}{\omega_e} = 8$.

It is interesting to investigate the effect of the electric and magnetic damping coefficients in one of the two proposed structures. If the metamaterial becomes lossy and the damping coefficients are no more zero. This is more realistic than considering lossless metamaterials. Figure 8 shows the transmittance profile for $\gamma_e = \gamma_m = 2\pi \times 0.1$ GHz in the DNM/air/DNM structure. As can be seen from the figure, the transmission peak does not reach unity and this can be attributed to loss. The most fascinating feature that can be seen in the figure is the sensitivity enhancement compared to Fig. 2. When the refractive index of the analyte layer changes from $n_2 = 1.00$ to $n_2 = 1.01$, the resonant wavelength shifts by an amount of $\Delta\lambda = 16.07$ μm as can be seen in Fig. 8. When the metamaterial was considered lossless, the shift in the wavelength was found to be $\Delta\lambda = 5.064$ μm as shown in Fig. 2. There is an improvement of 217% due to the loss of the metamaterial.

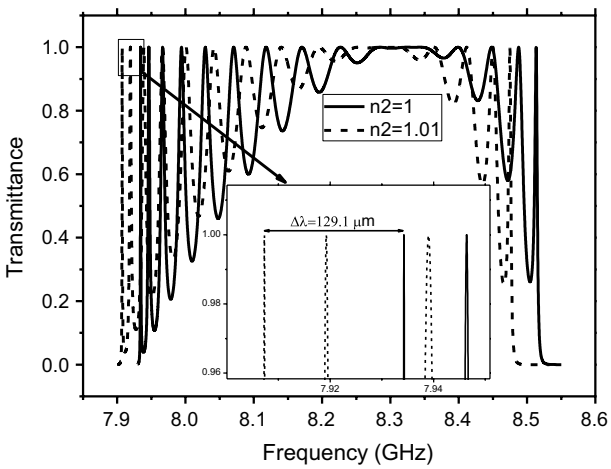

Fig. 6 Transmittance versus frequency for the ternary photonic crystal consisting of ENM/air/ENM for different values of n_2 for $N = 16$, $d_1 = 12$ mm, $d_2 = 6$ mm, $d_3 = 12$ mm, $\varepsilon_a = 1.21$, $\mu_a = 1$, $\omega_{pe} = \omega_{pm} = 2\pi \times 10$ GHz, $\gamma_e = \gamma_m = 0$ and $\frac{\omega_{pe}}{\omega_e} = \frac{\omega_{pm}}{\omega_e} = 10$

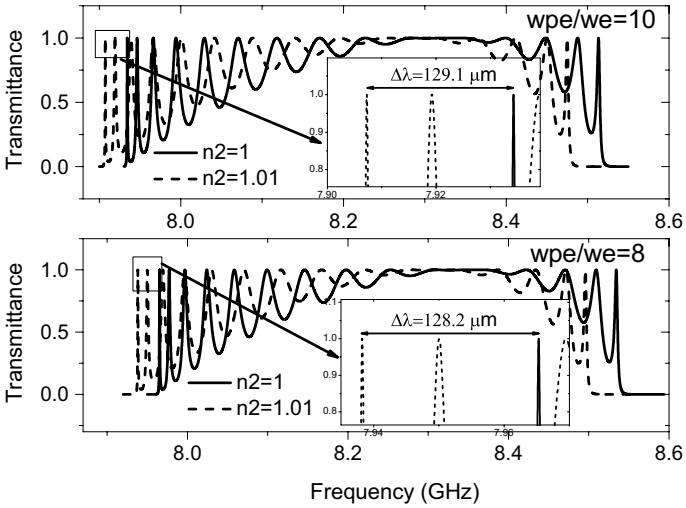

Fig. 7 Transmittance versus frequency for the ternary photonic crystal consisting of ENM/air/ENM for different values of n_2 for $N=16$, $d_1=12$ mm, $d_2=6$ mm, $d_3=12$ mm, $\varepsilon_a=1.21$, $\mu_a=1$, $\omega_{pe}=\omega_{pm}=2\pi\times10$ GHz, and $\gamma_e=\gamma_m=0$. The figure is plotted for two values of ω_{pe}/ω_e

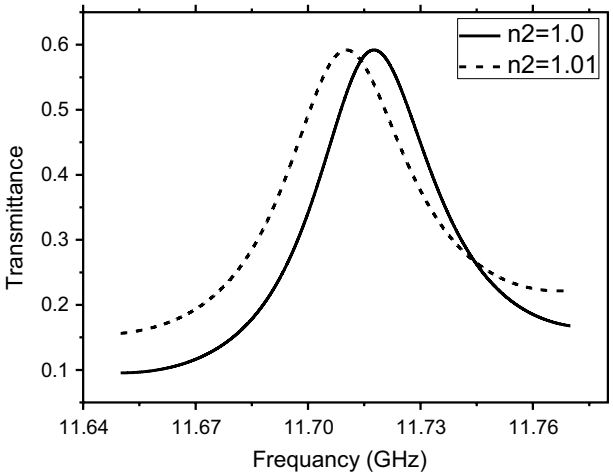

Fig. 8 Transmittance versus frequency for the ternary photonic crystal consisting of DNM/air/DNM with two lossy metamaterials for two different values of n_2 for $N=16$, $d_1=12$ mm, $d_2=6$ mm, $d_3=12$ mm, $\varepsilon_a=1.21$, $\mu_a=1.2$, $\omega_{pe}=\omega_{pm}=2\pi\times10$ GHz, $\gamma_e=\gamma_m=2\pi\times0.1$ GHz, and $\frac{\omega_{pe}}{\omega_e}=\frac{\omega_{pm}}{\omega_m}=10$

4 Conclusion

Two ternary photonic crystals were proposed as sensors for detection of small changes in the index of an analyte layer. The photonic crystals were assumed to have the structures DNM/air/DNM and ENM/air/ENM. The transmission spectra from these two structures were investigated and the shift in these spectra due to the variation in the index of

refraction of the analyte was determined. It was found that both structures are sensitive to any change in the index of an analyte layer. When the index of refraction of an air layer changes by $\Delta n = 0.01$, the shift in the wavelength is about $\Delta\lambda = 5.064$ μm in the structure DNM/air/DNM. This shift is a good shift that can be defected with recent optoelectronic devices. Moreover, the sensitivity of the structure DNM/air/DNM can be enhanced with the increase of ε_a, μ_a, and the ratio ω_{pe}/ω_e.

The structure ENM/air/ENM exhibited much greater sensitivity. It showed a wavelength shift of $\Delta\lambda = 129.1$ μm for a change in the analyte index of 0.01. This means that the structure ENM/air/ENM is much more sensitive to variations in the index of an analyte layer. It is about 26 times of the sensitivity of the DNM/air/DNM structure.

It is worth mentioning an example on how to detect the wavelength shift in this low energy region. In a recent paper, the realization of archimedes spiral antenna for a radar detector was investigated, where this radar detector can be employed to detect radar signal transmission within the frequency range of 2–18 GHz (Wahab et al. 2013). This antenna was fabricated to cover multiple bands: S band (2–4 GHz), C band (4–8 GHz), X band (8–12 GHz) and Ku band (12–18 GHz). It has a spiral shape with a radius of 2.5 cm (Wahab et al. 2013). We believe that this antenna can be used to detect the wavelength shift in the proposed sensor.

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Results in Physics 10 (2018) 55–60

Contents lists available at ScienceDirect

Results in Physics

journal homepage: www.elsevier.com/locate/rinp

Numerical study on optical properties of non-circular metamaterial optical fiber

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ARTICLE INFO

Keywords:
Metamaterial
AMM cladding
Birefringence
Elliptical core
Confinement loss

ABSTRACT

A non-circular core fiber with a metamaterial cladding using gold is proposed. The mode confinement properties of the disclosed fiber are investigated under various metallic (gold) and dielectric (Al_2O_3) thickness for different wavelengths and different elliptic ratios of 0.8 μm and 0.9 μm. The parameters like birefringence, confinement loss and dispersion are numerically analyzed theoretically using finite element method (FEM). The overall performance of the proposed fiber is studied and the results show that the fiber exhibits a stable relation between birefringence and confinement loss.

Introduction

Metamaterials are the man-made materials with unusual properties which are not found in nature and it possess electromagnetic properties ranging from radio frequency and microwaves up to optical frequencies [1]. Their properties arise from the structure rather than the materials it is made up of. Metamaterial refers to the material which has its properties beyond the natural materials as the Greek word "meta" means beyond [2] and is also referred as negative index materials (NIM) as they have the negative real part of permittivity and permeability respectively [3]. These metamaterials are made up of complex materials like metals, its oxides or plastics even to have unique behavior like negative refraction, anti-forward propagation [4,5], sub diffraction [6], cloaking[7] and so on. This metamaterial provides an interesting research area for scholars, by allowing skeletonizing it with chosen materials and even enabling their properties controllable during process with suitable procedures. Tunable based metamaterial filter, frequency selective surface and nonlinear metamaterials are the various types of metamaterials that can be designed and utilized for various applications [8].Ideally the mode propagation is uniform in circular core fibers. But practically it is not uniform and it has slightly different group and phase velocities. In addition to that perturbations in fiber such as twist, bend and stress produces a birefringence in the fiber, which changes the phase and signal strength with time and temperatures. Hence birefringence analysis becomes important. The applications of metamaterials include, sensors [9], isolators [10], ring resonators [11], antennas [12], splitters [13] and so on, as it can be integrated with all other technologies with a great ease. In this paper, we propose an anisotropic metamaterial (AMM) cladding with a hollow elliptical core with different metal-dielectric concentrations for wavelengths ranging from 300 nm to 900 nm. Recent analysis of circular core metamaterial fiber [14] with air core guidance [15] to show the electromagnetic propagation effect throughout the length of waveguide structure and stopping the light guidance [16] is exhibited. Recently, mahalakshmi et al., proposes the elliptical air core [17] with silver metal property to study the birefringence character and the same structure has been followed. This paper deals the metamaterial property due to adding gold with dielectric and analysis the optical properties is numerically analysis with different metal and dielectric concentrations as well as ellipticity ratios (see Fig. 1)

Design methodology

An equal proportion of metal (gold) and dielectric (Al_2O_3) for an anisotropic metamaterial layer is taken into account which could be varied later. Metal and dielectric layers are mounted alternatively and rolled up forming a cylindrical waveguide which has its core disturbed to be elliptical (eg: semi major axis as 1.8 μm and semi minor axis to be 2 μm).

The effective permittivity which has vital part in personalizing the

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https://doi.org/10.1016/j.rinp.2018.05.023
Received 25 February 2018; Received in revised form 12 April 2018; Accepted 11 May 2018
Available online 17 May 2018

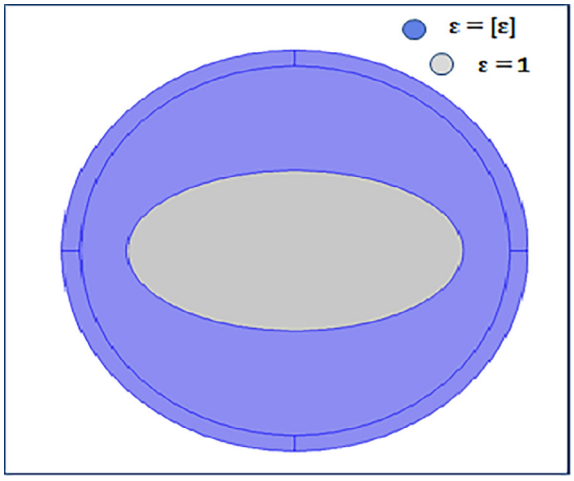

Fig. 1. Cross-sectional view structure (ε-effective permittivity, [ε]-tensor form of permittivity) with cladding 3 μm, core having the semi major axis b = 2 and semi minor axis a= 1.8 μm of ellipse.

structured AMM is calculated in tensor form using the formula [18] below as,

$$[\varepsilon^{eff}] = \begin{bmatrix} \varepsilon_{\perp}cos^2(\varphi) + \varepsilon_{\parallel}sin^2(\varphi) & (\varepsilon_{\perp}-\varepsilon_{\parallel})\sin(\varphi)\cos(\varphi) & 0 \\ (\varepsilon_{\perp}-\varepsilon_{\parallel})\sin(\varphi)\cos(\varphi) & \varepsilon_{\perp}sin^2(\varphi) + \varepsilon_{\parallel}cos^2(\varphi) & 0 \\ 0 & 0 & \varepsilon_{\parallel} \end{bmatrix} \quad (1)$$

where, $[\varepsilon^{eff}]$ is the effective permittivity of the AMM, φ refers the incident angle of light energy.

$\varepsilon_{\perp}$,$\varepsilon_{\parallel}$-Perpendicular and parallel components of $[\varepsilon^{eff}]$.

The calculated permittivity tensor value is both real and imaginary terms. The relation between perpendicular and parallel components of $[\varepsilon^{eff}]$ and metal-dielectric concentration has to be found to calculate the effective permittivity using the above formula. Hence we need to know the values of both $\varepsilon_{\perp}$ and $\varepsilon_{\parallel}$ which is given as,

$$\varepsilon_{\perp}^{eff} = \frac{(C_m + C_d)\varepsilon_m\varepsilon_d}{C_d\varepsilon_m + C_m\varepsilon_d} \quad (2)$$

$$\varepsilon_{\parallel}^{eff} = \frac{C_m\varepsilon_m + C_d\varepsilon_d}{C_m + C_d} \quad (3)$$

where, ε_m and ε_d being the permittivity of the metal and dielectric and the expression has been noted and its effective permittivity with function of wavelength has been calculated and plotted in [17] where C_m, C_d implies the ratio of concentration of metal and dielectric in the whole structure that forms the desired AMM fiber. Thus from Eqs. (1)–(3), it is noticed that any change in C_m and C_d, changes the value of effective perpendicular and parallel components, whose effect is realized in the effective permittivity and thus confinement characteristics of provided wavelength is altered. A variation in effective permittivity for different wavelengths is the desired anisotropy which is plotted for different metal and dielectric concentrations with real and imaginary terms isolated. Hence, it is observed that the field propagation in either core mode or cladding mode is decided by metal/dielectric combinations and its medium parameters (parallel and perpendicular components). In this paper, we investigate the characteristics like effective mode index, birefringence, confinement loss and dispersion using FEM at two different combinations of metal/dielectric thickness ($C_m = C_d = 0.5$ and $C_m = 0.25, C_d = 0.75$ thus making $C_m < C_d$). Using above equations, the pulse propagation in proposed fiber is shown below

The mode deviation and the electric field distribution of the proposed fiber are given below,

It is noted that as the two kinds of definite modes is generated as the proposed structure is in elliptical, which is inferred through the deviations in the arrow directions.

Its corresponding mode index of fundamental modes (LP_{01}&LP_{11}) for both the cases ($c_m = c_d$ & $c_m < c_d$) is calculated and values is plotted for ellipticity ratio of 0.8 and 0.9 as shown below in Fig. 2. Each mode is identified by Electric field distribution which is shown by arrow mark indicated by red line.

Similarly, the variation of effective mode index is studied with function of wavelength for ellipticity ratio as 0.8 and 0.9. The calculated mode index is plotted with two diiferent case of metal dielectric such that in equal proportion and higher proportion of dielectric than the metal.

Fig. 3 and 3(a) clearly shows that the modal index variation is decreased with increasing of wavelength. It implies the pulse propagation speed is drastically increasing with dropping modal index (see Fig. 4).

Asymmetrical mode propagation with distinct polarization

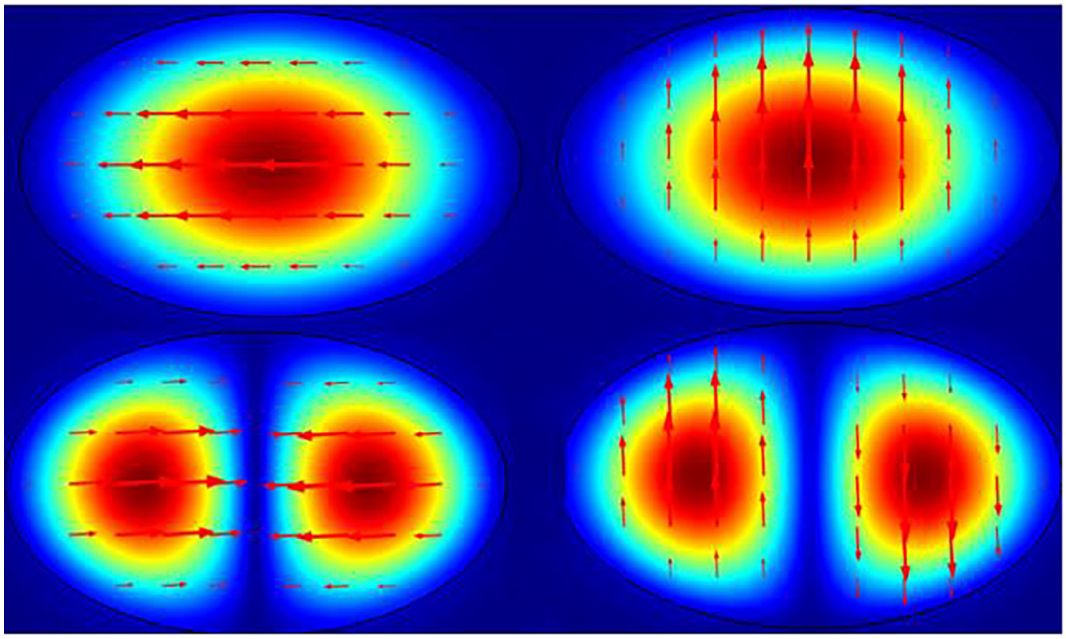

Fig. 2. Propagation of x and y polarized modes of LP_{01} and LP_{11} .for $C_m = C_d$ at the wavelength of (i) 300 nm and (ii) 500 nm.

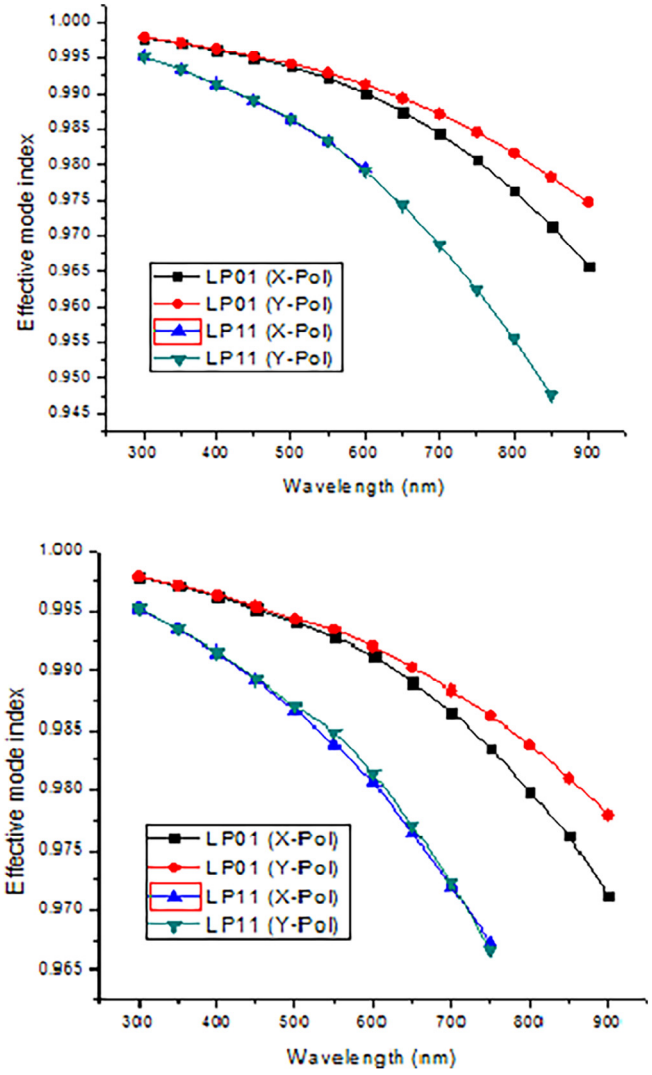

Fig. 3. Wavelength dependent mode index (a) When $C_m = C_d$ for ellipticity ratio of 0.8 (b) When $C_m < C_d$ for ellipticity ratio of 0.8.

directions (X and Y) gives rise to even and odd modes which is mainly due to the disturbed core. In an elliptical core, a difference in index arises as the light pulse propagates through and this causes inequality in speed of x and y components resulting in a temporal shifting/time difference in detector. The shifted pulse is the effect of index difference between fast and slow axis (x and y) respectively. This index difference is coined as "birefringence" of a fiber which can be perturbed byfiber strucutre. The birefringence is expressed mathematically as,

$$B = |n_x - n_y| \tag{4}$$

Where, n_x and n_y are the refractive indices for orthogonally polarized x and y modes, X and y- polarized even/odd modes are generated bythis induced birefringence. The modes are identified by their field direction. When field direction is uniform, then it is taken as even modes and if the field direction is not uniform, then it is accounted as odd modes. The effective mode index for each polarization under different wavelengths and metal- dielectric concentration is generated and the birefringence effect is studied. The calculation plotted for each case is shown below,

Results and discussions

In this proposed design, an ideal *meta*-fiber with elliptical core having anisotropic medium parameters ($\varepsilon_{\perp}$,$\varepsilon_{\parallel}$) is simulated using

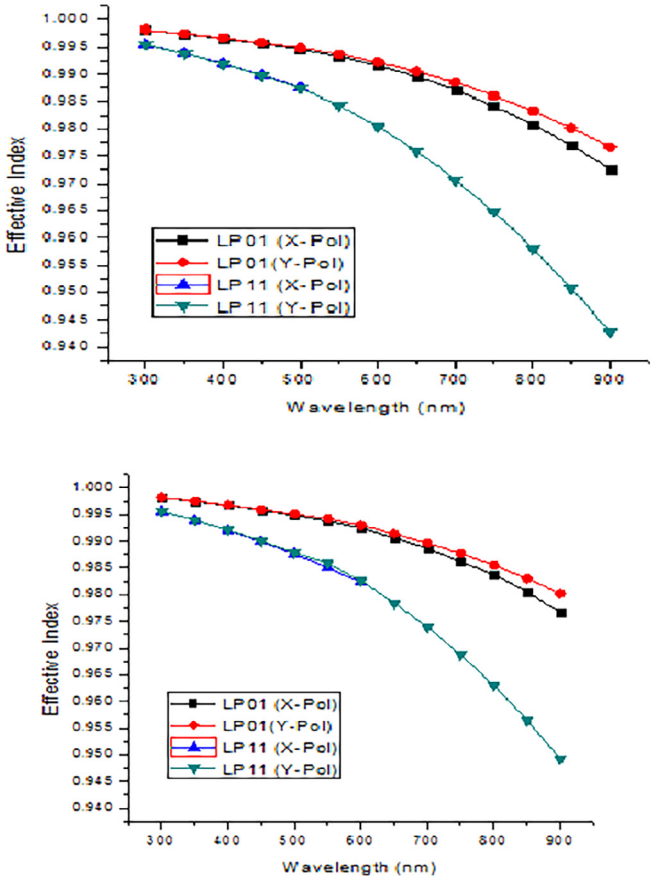

Fig. 3(a). Wavelength dependent mode index (a) When $C_m = C_d$ for ellipticity ratio of 0.9 (b) When $C_m < C_d$ for ellipticity ratio of 0.9.

COMSOL Multiphysics for two different ellipticity ratios. It is observed that the mode propagation along the hollow elliptical core is influenced by the changing values of effective permittivity for different wavelengths and for two different metal- dielectric concentrations ($C_m = C_d$ and $C_m < C_d$). For an incident wavelength, the fundamental LP_{01} modes and the auxiliary LP_{11} modes are identified for the proposed structure.

Since the core is elliptic, birefringence is taken into account and it is calculated theoretically using Eq. (4) and plotted as a function of wavelength for different concentration of metal and dielectric as shown in Fig. 4.

The variation of mode propagation is in our proposed structure is distinguished by the filed distribution which could be calculated by Eq. (4) and plotted which exhibits its linear birefringence. It is noted here that mode propagation of index difference of LP_{01} is prolonging than LP_{11} for each case of ($C_m = C_d$ & $C_m < C_d$). But the mode propagation of index difference for LP_{11} is sustained as increasing of dielectric concentration than metal concentration.

The other most desirable parameters are confinement loss and dispersion expressed as follows,

$$\alpha = 8.686 \times \frac{2\pi}{\lambda} \times 10^6 \times Im(n_{\text{eff}}) \tag{5}$$

$$D = \left(\frac{c}{\lambda}\right)\left(\frac{d2n_{eff}}{d\lambda^2}\right) \tag{6}$$

The calculated confinement loss for various metal-dielectric concentration ($C_m = C_d$ and $C_m < C_d$) and ellipticity ratio is plotted as shown below. Due to the uniform behavior of loss in both ellipticity ratio, here we have shown the loss spectra for any case (ER = 0.8) at equal metal-dielectric concentration & metal < dielectric

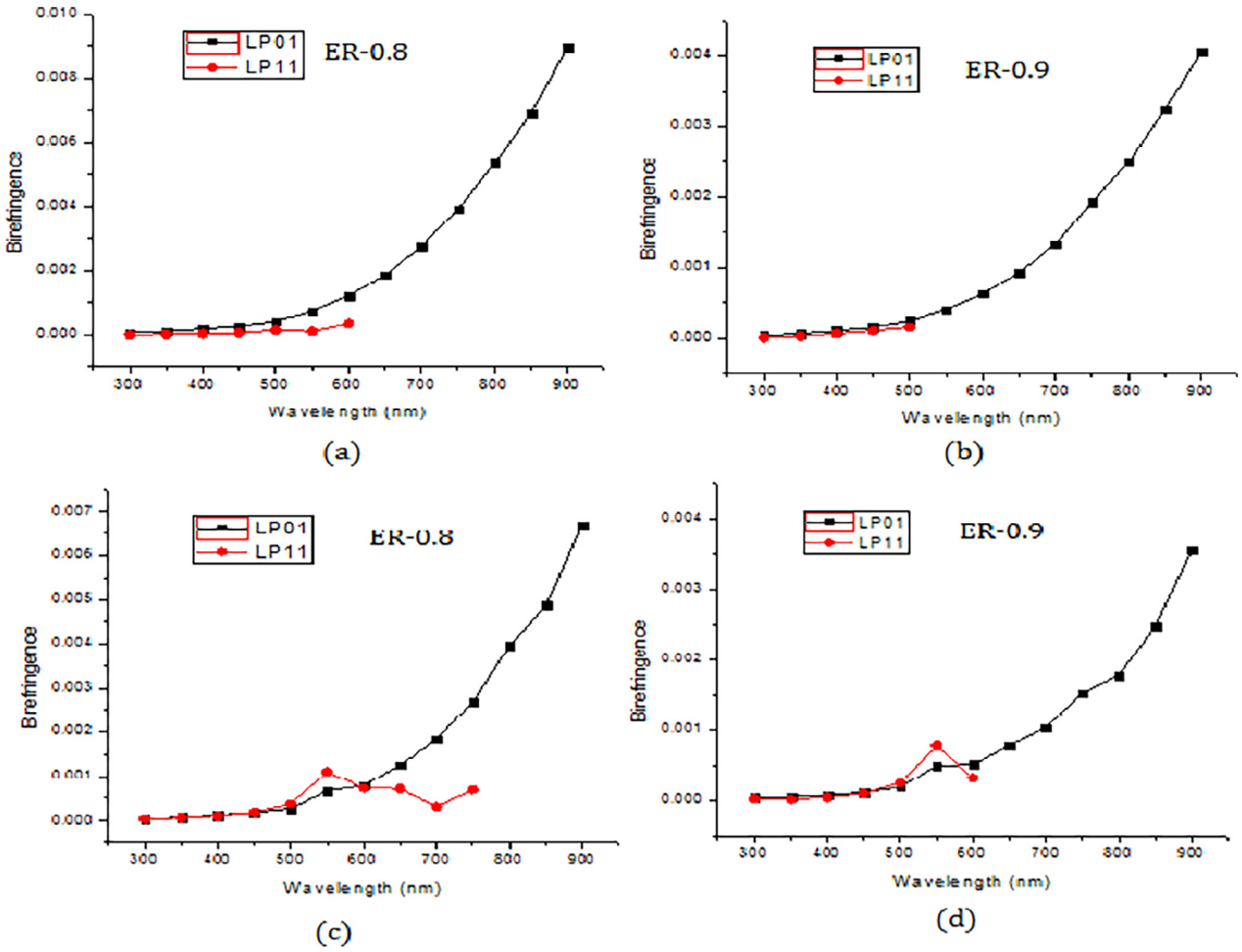

Fig. 4. Variation of birefringence with different thickness of metal and dielectric layer and different ellipticity of 0.8 & 0.9.

concentration.

From the Fig. 5, it is clear that the behavior of loss spectra exhibits as linearly increasing and attains it maximum at particular wavelength then it gradually decreased and continues the same behavior for the range of wavelength for Figs. 5(a) and 5(b). The loss spectra will maximum for equal *meta*-dielectric concentrations whereas it will be reduced at the case of metal < dielectric concentrations. Similarly, the calculated value of dispersion for proposed structure is shown below

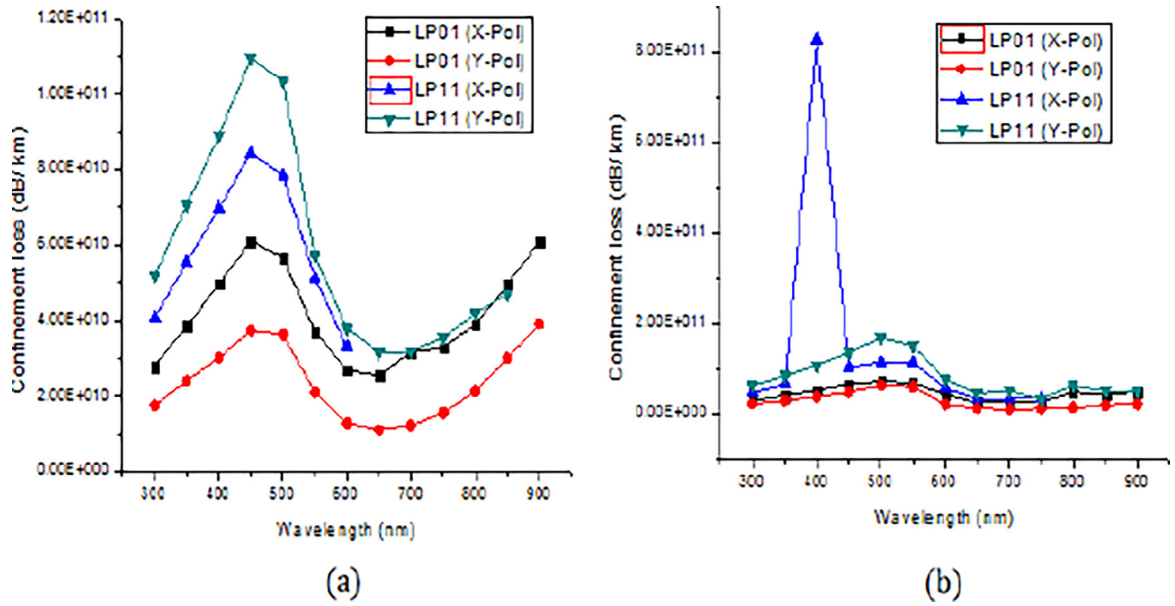

Fig. 5. Variation of confinement loss for $C_m = C_d$ with ellipticity ratio of 0.8 b) Variation of confinement losses for $C_m < C_d$ with ellipticity ratio of 0.8.

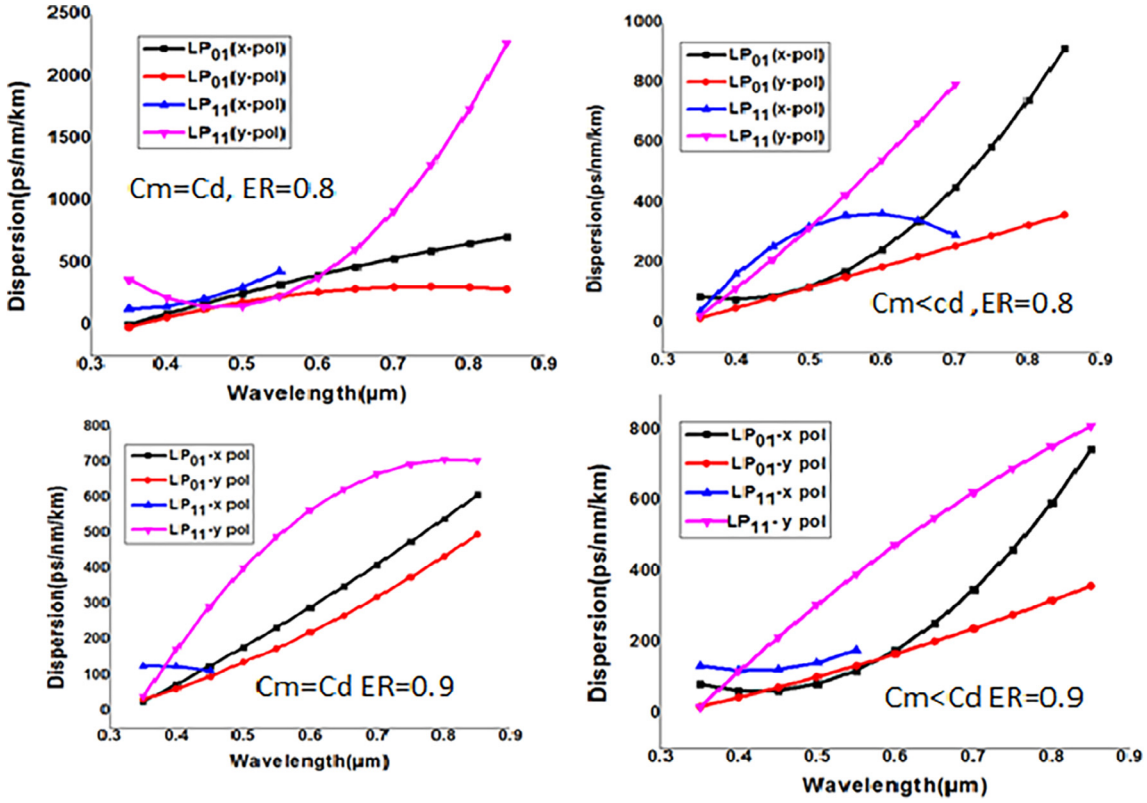

Fig. 6. dispersion variation for different wavelength at ($C_m = C_d$ & $C_m < C_d$), (a) & (b) at ER = 0.8. (c) & (d) at ER = 0.9. The plotted values are also tabulated to show the deviation of optical properties with respect of ellipticity at the particular wavelength of 900 nm.

Table 1
Comparison table of optical properties at 900 nm.

Ellipticity	0.8		0.9	
	$C_m = C_d$	$C_m < C_d$	$C_m = C_d$	$C_m < C_d$
Dispersion (ps/nm/km) for LP_{01}	720	960	680	770
Birefringence for LP_{01}	0.010	0.0069	0.004	0.0037

(see Fig. 6).

The Table 1 shows that the dispersion values get increasing when thickness of metal and dielectric layer tends to increase. Similarly the high birefringence values have been shown for equal proportion of metal and dielectric at the ellipticity ratio of 0.8. Hence, it is analyzed that the calculated optical properties are highly appreciable performance at the ellipticity ratio 0.8

The variation of second order dispersion gives the linear variation of LP_{01} and non-linear variation of LP_{11} at entire wavelength. Such a variation gives the information about the proposed structure which gives the lower efficiency in communication system and high stable and good impact of sensing devices. The maximum loss spectra give its corresponding resonant wavelength which provides key path for finding sensitivity. In regards of communication application, the other metal such as silver makes good responsibility.

Conclusion

We have proposed a novel design of elliptical core anisotropic metamaterial for different metal (Au)–dielectric (Al_2O_3) concentration and for different ellipticity. By the presence of anti-symmetric nature in proposed structure, it experiences a birefringence effect which characteristics have been studied for LP_{01} and LP_{11} for the function of wavelength and also some other essential parameters like confinement loss and dispersion is analyzed for different ellipticity (0.8 & 0.9). Finally we inferred here that addition of gold leads to good application for making sensor device using metamaterial.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.rinp.2018.05.023.

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Optical Materials 84 (2018) 545–549

Contents lists available at ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat

Silicon nano crystal filled photonic crystal fiber for high nonlinearity

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ARTICLE INFO

Keywords:
Photonic crystal fiber
Nonlinearity
Numerical aperture
Confinement loss
Silicon nano crystal

ABSTRACT

A novel design of circular hybrid photonic crystal fiber (CH-PCF) with high nonlinearity and high numerical aperture (NA) is introduced in this paper. The numerical simulation results are obtained by using finite element method (FEM) and selecting finer mesh. Some fundamental optical parameters such as nonlinearity, effective area, scattering loss, power fraction and NA for the two orthogonal polarized modes are rigorously evaluated. Significant improvement of PCFs in terms of the non-linearity and NA are demonstrated by carefully investigating of the geometrical parameters of structure. The reported design undoubtedly confirms high nonlinearity of 128873.1183 $W^{-1}km^{-1}$ for x-polarization and 152134.1052 $W^{-1}km^{-1}$ for y-polarization respectively at the optical wavelength of 0.5 μm. Simultaneously, outmost NA of 0.57 and 0.59 are found at optical wavelength $\lambda = 2.5$ μm. So, the obtained outcomes make the proposed PCF a prominent candidate in super continuum generation as well as all optical signal processing applications.

1. Introduction

Photonic crystal fiber is new types of optical fiber where cylindrical shape air holes run through the total fiber. Low-loss periodic dielectric medium based photonic crystal fiber is built by utilizing a periodic array of tiny air holes which is run along the whole fiber length. For showing broadened optical properties, PCFs or microstructure holey fibers are best fitted with some new applications, for example, fiber sensors and capacity to maintain high polarization, super continuum generation, broadband dispersion controlling four wave mixing, all optical signal processing and so on. In PCFs, nonlinearity is one of the most fundamental possessions for some applications including optical switching, optical parameter amplification, optical regeneration, super continuum generation, and optical wavelength conversion [1,2]. Besides microstructures PCFs are also found in some wonderful applications such as all optical logic gates [3], optical demultiplexer [4], optical switch [5] and many more. PCFs have numerous tunable properties, for instance; air hole distance diameter, pitch, cladding, background material, doped core and so on. These adaptabilities give better control over nonlinearity, confinement loss, NA, effective mode area. These are achievable in PCF but unachievable in single mode fibers (SMFs). PCFs are mainly characterized into two concentrations, one is index guiding (IG) and the others is photonic band gap (PBG) PCFs. In these PCFs, in the middle of core and cladding high refractive index contrast is strictly maintained for optical guidance.

To accomplish proficient nonlinear procedures, PCFs are very well known, for example, all optical wavelength transformation, optical parametric amplification and super continuum generation [6,7] etc. are the most attracted incredible interests [8,9].

To accomplish high nonlinearity, researchers have considered the conduct of PCFs by utilizing nanostructure core with high refractive index. Pure silica core of a PCF make nonlinear coefficient is very low just around 100 $W^{-1}km^{-1}$. The scenario of the matter is that the nonlinear refractive index of silica is soft, nominally 29.6×10^{-21} $W^{-1}m^2$. To enhance high nonlinearity, higher nonlinear refractive index based materials are embedded inside the core region. Recently, Liao et al. [10] proposed a PCF of high nonlinearity utilizing nano scale slot core. The PCF displays a high nonlinearity up to 3.5739×10^4 $W^{-1}km^{-1}$ at the optical wavelength $\lambda = 1.55$ μm. Huang et al. proposed a slot coiled silicon PCF having a high nonlinear coefficient up to 1068 $W^{-1}km^{-1}$ [11]. In both articles, the structure leads to the fabrication complication due to the use of slot inside the

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https://doi.org/10.1016/j.optmat.2018.07.054
Received 23 April 2018; Received in revised form 18 July 2018; Accepted 20 July 2018

core region. Li and Zhao utilized nano wires of gold in center and it supports polarization dependent coupling and transmission [12]. Liao et al. [13] recommended a winding PCF of high nonlinearity showing nonlinear coefficient of 226 W^{-1} km^{-1} at the communication band. In the year 2016, Amin et al. [14] proposed a spiral shape photonic crystal fiber employing GaP strips inside the core for high nonlinear purpose. It demonstrates a high nonlinearity order of 10^4 W^{-1} km^{-1} through the investigational electromagnetic spectrum. In any case, fiber shows confinement loss of 10^3 dB/km and 10^{-10} dB/km for x and y polarization modes, individually at 1550 nm wavelength. To create strands having huge nonlinearity with nanoscale slot core, recently article [15] is published. Slot bismuth PCFs are proposed by K. Saitoh et al. [16]. It also certified the high nonlinear coefficient of 11 W^{-1} m^{-1} at the electromagnetic wavelength λ = 1.55 μm. Very recently in 2018, another nanoscale GaP strips based silicon PCF is introduced in the article [17] and it achieves ultrahigh nonlinear coefficient of 63435.74 W^{-1} km^{-1} at the controlling wavelength λ = 1.00 μm.

In the presented article, CH-PCF is proposed for high nonlinear applications. The geometric structure of the proposed PCF is very simple. Moreover the air cavities of the PCF are perfectly circular. To best of our knowledge this types of PCF has not been previously published for such type of applications. The suggested PCF demonstrated a high nonlinear coefficient up to 128873.1183 W^{-1} km^{-1} and 152134.1052 W^{-1} km^{-1} at the optical wavelength λ = 0.5 μm for the fundamental x-polarization and for y-polarization, respectively. As far as anyone is concerned, this is the most beneficial outcome contrasted with recently published articles. In this manner, proposed fiber can be helpful for super continuum generation, optical parameter amplification and all optical signal processing applications.

2. Fiber design and theory

The geometric perspective of the proposed CH-PCF with amplified sight of slot core is exhibited in Fig. 1(a) cladding region and (b) core region embedded with silicon nano crystal. The outline is kept as basic as it could reasonably be expected. The cladding region is engineered with perfectly circular shape air holes. The first three layers of the cladding air holes rings are organized in hexagonal manner and rest of two layer rings are positioned in circular manner. It means. The air gap distance across in cladding distance, d = 1.40 μm and 1.50 μm with the pitch estimation of Λ = 1.60 μm. Air filling portion in the cladding region is formatted by d/Λ. Adapting with the manufacturing possibility the air filling fractions (AFF) are strictly preserved. In this work, a reasonable AFF of < 0.93 is regarded. Because high value AFF of any PCF is a key factor which directly leads fabrication hindrance. The foundation material is silica which is commercially available. Besides silica has some extraordinary optical behaviors such as high optical transitivity, low loss, inert with water or chemicals (i. e. acid, base etc). The inner region of the proposed PCF is embedded with optical material of silicon nano crystal. Nonetheless an absorption boundary PML with depth 10% of cladding diameter has been employed. PML boundary plays a significant role by diminishing undesirable nonphysical electromagnetic radiations. The mode field distributions of the proposed structure are exhibited in Fig. 2 (a) x-polarization and (b) y-polarization at λ = 1.55 μm. It is nicely comprehended the small effective mode area for both orthogonal polarizations. This small zone of the compelling mode gives ascent of huge nonlinearity.

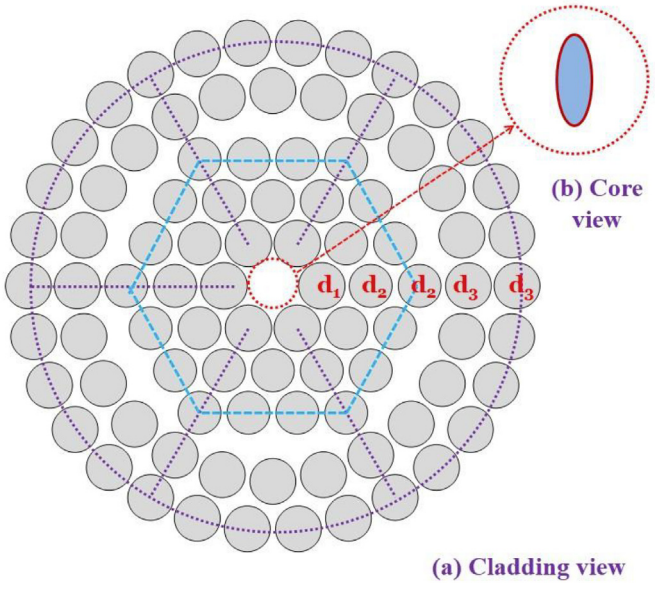

Fig. 1. The end faces cross sectional view of microstructure PCF; (a) cladding region and (b) core region embedded with silicon nano crystal.

3. Numerical methods and results analysis

Numerical investigation is a vital portion for characterization designed model. In this work, the state and art of the PCF has been done by FEM based commercially accessible software package COMSOL Multiphysics version 4.2. Moreover it takes less computer memory and computational time for electromagnetic investigation. Number of degrees-of-freedom (DOF) is fixed here and 48,547 are found from the indicated model. FEM provides the propagation constant spontaneously having more accurate result by solving the matrix eigenvalue problem even the structural mensuration is more complex. The base material is pure silica. The refractive index of silica is dependent on electromagnetic wave. There is also established an imperial relationship for the determination of the refractive index. In the year of 1871, Wilhelm Sellmeier developed an equation as follows

$$n^2(\lambda) = 1 + \sum_i^3 \frac{B_i \lambda^2}{\lambda^2 - C_i} \tag{1}$$

Where, B_i and C_i are the sellmeier coefficients of silica and λ is the controlling wavelength in μm unit.

Optical power flows through the fiber core for propagation mode. Power flow distribution is not same for core, cladding and material. So core, cladding and material paper fraction has been investigated for better realization using the imperial relation. Besides, there are found two fundamental modes like X-polarization and Y-polarization for propagation constant β. Very small variation exists in refractive index for these two orthogonal polarizations. The power fraction (in %) can be calculated by the following relationship.

$$Power\ Frtaction\ (\eta') = \frac{\int_X S_z dA}{\int_{All} S_z dA} \tag{2}$$

Where, x is the area of interest (i. e. core, cladding and material) and all means cross sectional entire area of that PCF. Estimation of the effective mode area is very much substantive. Effective mode area or effective area (EMA) is the prerequisite for resolving nonlinearity as well NA. The nonlinearity and the NA can be calculated by the following equation as follows.

$$A_{eff} = \frac{(\iint |E(x, y)|^2 dxdy)^2}{\iint |E(x, y)|^4 dxdy} \tag{3}$$

Where, E(x,y) is the modal field distribution. Now nonlinearity and NA can be computed by the following mathematical expressions

$$Nonlinearity\ (\gamma) = \frac{2\pi}{\lambda} \times \frac{n_2}{A_{eff}} \tag{4}$$

Here, n_2 represented nonlinear coefficient of equation (4), of the optical material embedded inside the core region. From the small size core area with comparative larger size air hole in the outer boundary of